To Propose an Improvement in Zhang-Suen Algorithm for Image Thinning in Image Processing

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Abstract

Thinning is the preprocessing stage to make easy higher level analysis and recognition for such applications like OCR, Fingerprint classification, Pattern recognition. In this paper we described thinning and its various algorithm. It is concluded that there are some loopholes in thinning algorithm. So there is a need to improve thinning rate. The thinning algorithm's performance has been analysed in terms of PSNR value, MSE value and thinning rate. To improve performance of the algorithm, enhancement has been proposed which is based on back propagation algorithm. The simulation results shows that proposed algorithm performs batter in terms of PSNR, MSE and thinning rate.

Keywords: Thinning rate, Image- Processing, Zhang-Suen, Skeletonization, Neural Network

I. INTRODUCTION

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. It is a type of signal dispensation in which input is image, like video frame or photograph and output may be image or characteristics associated with that image[3].Usually Image Processing system includes treating images as two dimensional signals while applying already set signal processing methods to them. It is among rapidly growing technologies today, with its applications in various aspects of a business. Image Processing forms core research area within engineering and computer science discipline. Image processing are computer graphics and computer vision. In computer graphics, images are manually made from physical models of objects, environments, and lighting, instead of being acquired from natural scenes, as in most animated movies [5]. Computer vision, on the other hand, is often considered high-level image processing out of which a machine/computer/software intends to decipher the physical contents of an image or a sequence of images.

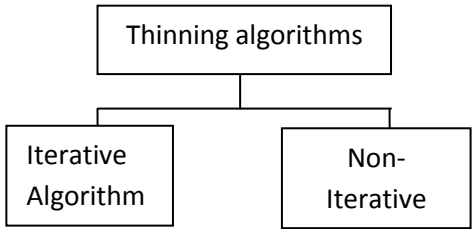
II. THINNING

Thinning is an image processing process in which binary valued image regions are condensed to lines that approximate the center skeletons of the regions. For each single image region it is usually required that the lines of the thinned result are associated, so that these can be used to infer shape and topology in the original image. A main idea behind thinning is in the preprocessing stage to make easy higher level analysis and recognition for such applications as Optical Character Recognition, fingerprint analysis, diagram understanding, and feature detection for computer vision [5].The skeleton of a binary image is an integral demonstration for the shape analysis and is useful for many pattern recognitions application. The skeleton of an object is a line connecting point's midway between the boundaries [3]. Thinning techniques have been applied in many fields such as automated industrial inspection, pattern recognition, biological shape description and image coding etc. The main objective of thinning is to improve efficiency, to reduce transmission time. The skeleton refer to the bone of an image [5]. Skeletonization is usually applied on binary images which consist of black (foreground) and white (background) pixels. It takes input a binary image, and produces another binary image as output. Skeletonization has been used in a wide variety of other applications like: Optical character recognition (OCR) [2,5] ,Pattern recognition[3], Fingerprint classification[4],Biometric authentication[5], Signature verification[5], Medical imaging[4].

A. Thinning Algorithms:

All the Thinning algorithms are classified into two broad categories:

1) Iterative thinning algorithm [3]
2) Non iterative thinning algorithm [3]



1) Iterative (Pixel Based)

This thinning algorithm produces a skeleton by examining and deleting contour pixels through an iterative process in either sequential or parallel way [3]. Sequential thinning algorithms which examine contour pixels of an object in a predetermined order, and this can be accomplished by either raster scanning or following the image by contour pixels. In parallel thinning algorithms, pixels are deleted on the basis of results obtained only from the previous iteration. Hence parallel thinning algorithms are suitable for implementation in parallel processors [3].

a) Sequential thinning:

This algorithm is that which inspect contour points in a predetermined order of an object and this .can be accomplished by either raster scanning or following the images by contour pixels.

b) Parallel Thinning:

In this type of algorithms pixels are inspect for deletions on the basis of some previous available iteration results.

2) Non-iterative (non-pixel based)

Thinning is not based on examining individual pixels. Without examining all the individual pixels, these algorithms produce a certain median or center line of the pattern to be thinned directly in one pass. Some popular non pixel based methods include medial axis transforms, distance transforms, and determination of centerlines by line following. Medial axis transforms often use gray-level images where pixel intensity represents distance to the boundary of the object [3]. Distance transform based methods compute the distance to the image background for each object pixel and use this information to determine which pixels are part of the skeleton.

III. LITERATURE REVIEW

In [2] the author proposes a new skeletonization algorithm which combines sequential and parallel approaches which comes under iterative approach. The algorithm is conducted in three stages. First two stages used to extract the skeleton and the third is used for optimizing the skeleton into one-pixel width. An experimental result shows that the proposed algorithm produces better results than the previous Skeletonization algorithms.

In [3] the author proposes two new iterative algorithms for thinning binary images. In the first algorithm, thinning of binary images is done by using two operations: edge detection and subtraction. Second algorithm is based on repeatedly deleting the pixels until a one pixel thick pattern in a binary image is obtained. Erosion conditions are devised to assure preserving connectivity. Experimental results show that edge based iterative thinning algorithm is time consuming as compared to optimized Skeletonization algorithm.

In [4] the author discusses wide range of skeletonization algorithms on binary images including pixel based deletion and non-pixel based deletion methods. Algorithms are discussed in details in this paper and relationships between the different skeletonization algorithms have also been explored. Various comparisons have been made between skeletons obtained from various skeletonization algorithms on the basis of subjective and objective criteria.

In [5] the author introduced a framework for making thinning algorithms robust against noise in sketch images. The framework estimates the optimal filtering scale automatically and adaptively to the input image. Experimental results showed that this framework is robust against typical types of noise which exists in sketch images, mainly contour noise and scratch.

In [10] the author performs thinning of binary images by repeating two sub-iterations: one deletes the south-east boundary points and the north-west corner points while the other one deletes the north-west boundary points and south-east corner points. Point deleting is done according to a specific set of rules. The two sub-iterations are repeated until no more points validate the deleting rules.

In [6] the author proposes a new sequential algorithm which uses flag map and bitmap simultaneously to decide whether a boundary pixel should be deleted or not. Three performance criteria are proposed in this paper for the comparison of proposed algorithm with other algorithms. Experimental results shows that the skeleton produced by the proposed sequential algorithm is not only one pixel thick, perfectly connected, well defined but are also immune to noise.

In [7] the author presents a novel rule-based system for skeletonizing. The author has presented a formal mathematical derivation which shows how the central lines are obtained and shape of the symbol remains connected. Experimental results are presented on symbols, characters, and letters written in different languages, and on rotated, flipped, and noisy symbols. The results show that the developed method is effective, and fast, and can thin any symbol in any language, irrespective of the direction of rotation.

IV. ZHANG-SUEN THINNING ALGORITHM

This algorithm is very fast and simple to be implemented. It has two sub-iterations. This method has a parallel method which shows that it has previous value on which it depended [7] .In the first one a pixel I (I, J) is deleted if the following conditions are satisfied:

1) Its connectivity number is one.
2) It has at least two black neighbours and not more than six.
3) At least one of I (I, j+1), I (i-1, j) and I (i, j-1) are white.
4) At least one of I(I-1,j), I(i+1, J) and I(I,j-1) are white.

In the second Iterations step 3 and 4 are changed.

1) Its connectivity number is one.
2) It has at least two black neighbours and not more than six.
3) At least one of I(i-1, j), I(I,j+1), and I(i,+1 j) are white.
4) At least one of I(I, j+1), I(i+1, J) and I(I,j-1) are white.

A 3*3 window is move down throughout the image and calculations are carried out at each pixels to decide whether it will stay on pixel or not.

At the end pixels which satisfied these conditions are deleted. If the end of the sub-iteration there is no pixel to analysis then algorithm stops.

V. PROPOSED METHODOLOGY

Most of the skeletonization algorithms suffer from traditional problems such as reducing to one pixel width of the skeleton, preserving geometrical and topological properties. Many of the algorithms have the problem of discontinuity in the images. Whereas, several techniques are failed to preserve the shape topology and not re-construct able. Spurious tails and rotating the text shape is other serious problem and due to this most of the thinning methods are failed.

A. Improved Zhang- Suen Algorithm

It is very popular and well proved algorithm for thinning of an image. This algorithm was proposed by Zhang and Suen in 1984. In base paper Zhang and Suen technique is used to thin some black and white pixels because this algorithm work on binary images. A new thinning algorithm with neural network is proposed using Zhang and Suen algorithm to produce a new thinning algorithm for better results.

B. Neural Network Approach

Thinning problem requires two tasks to be implemented: (a) peeling the thick pixels off (b) stopping the peeling process when the pixel size reduces to exactly one. The first can be achieved with relative ease. The main difficulty arises in the second part, because the stopping decision must be done automatically. This can be achieved using a real time cellular neural network by training the neural network. Most of the conventional thinning approaches suffer from noise sensitivity and rotation dependency. With the use of neural networks we can perform thinning invariant under arbitrary rotations.

The back propagation algorithm prepares a given feed-forward multilayer neural network for a given arrangement of input patterns with known classifications.

The algorithm can be deteriorated in the accompanying four stages:

1) Feed-forward computation
2) Back propagation to the output layer
3) Back propagation to the hidden layer
4) Weight updates

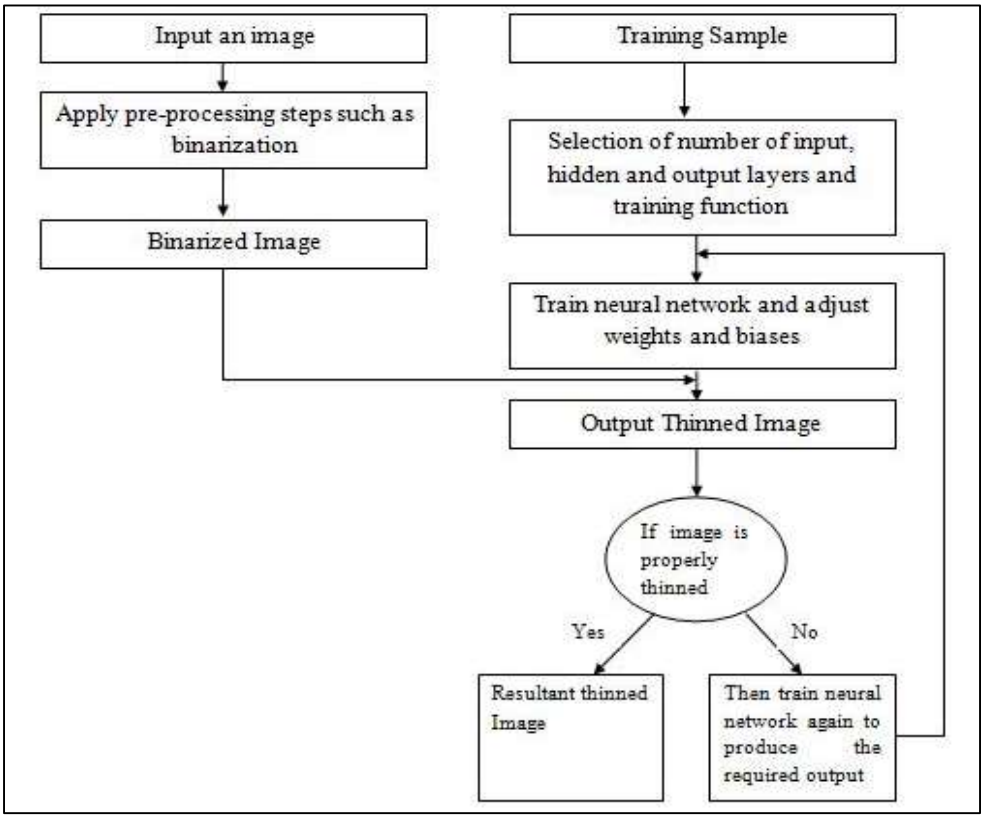


Fig. 5.1: Proposed Methodology 1

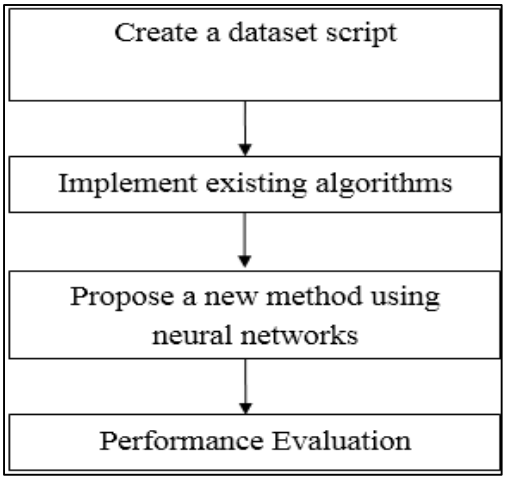


Fig. 5.2: Proposed Methodology 2

C. *The Main Steps are Described Below*

1) Create a dataset script.
2) Implementing existing algorithms: To implement the existing skeletonization algorithms using neural networks.
3) Proposing a new Method for skeletonization using neural networks.
4) Evaluating Performance: To evaluate the performance of existing algorithms and new proposed method for skeletonization using neural networks on the basis of some performance measures:
   1) Execution Time: The time taken to obtain the output skeletons for a particular image.
   2) Thinning Rate: The degree to which an object is said to be thinned or completely thinned can be measured in terms of thinning rate.

VI. EXPERIMENTAL RESULTS

The proposed scheme is implemented on MATLAB.

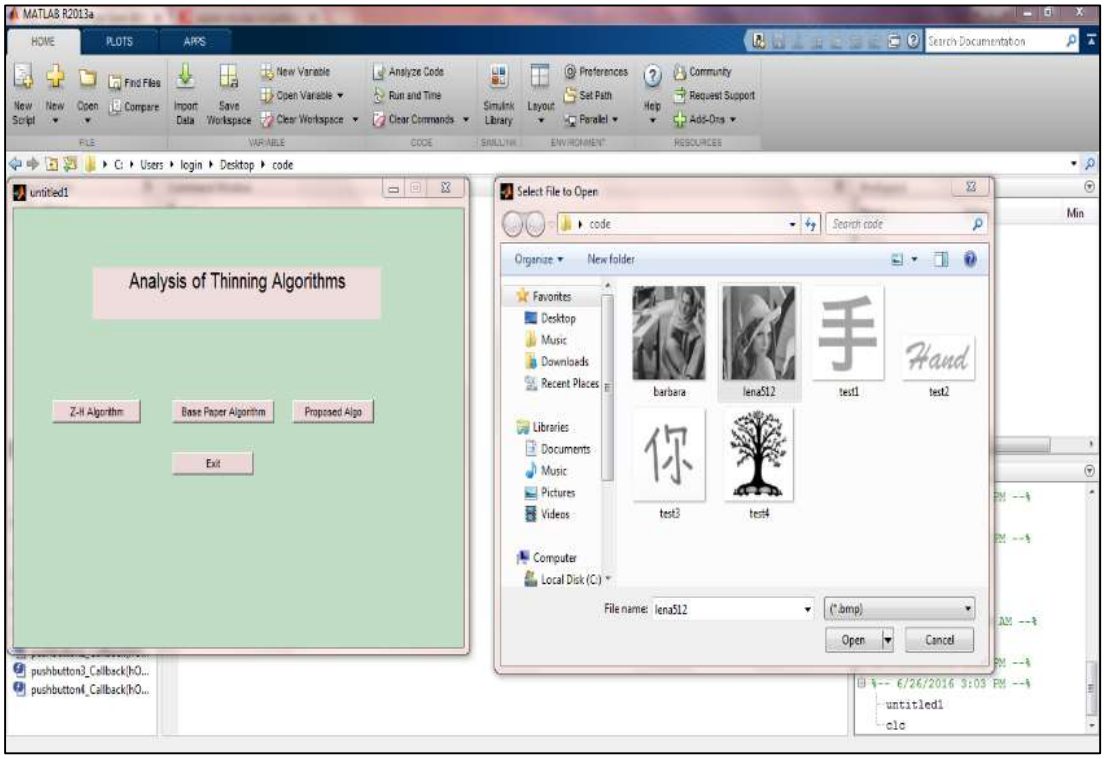


Fig. 6.1: Image Loaded

First Step is to load the image for thinning.

Fig. 6.2: Image Consist of Black & White Pixels (Binarized Image)

Supposed the known target line is marked as 1 i.e. foreground point, and background point that need not to be skeletonized is marked as 0.

Fig. 6.3: Thinned Image using Zhang-Suen Algorithm

The image is loaded for the thinning. The thinning is technique of removing the unwanted data from image. To remove the unwanted data from the image thinning elements is used which will remove unwanted data. The Zhang and Suen algorithm is used for thinning which gave output in terms of MSE, PSNR and thinning rate.

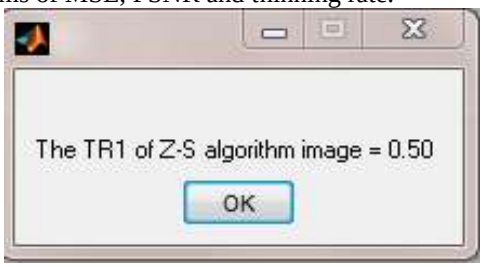


Fig. 6.4: The Thinning rate of Zhang-Suen algorithm is 0.50

Fig. 6.5: Value of MSE is 616.73, Value of PSNR is 20.26

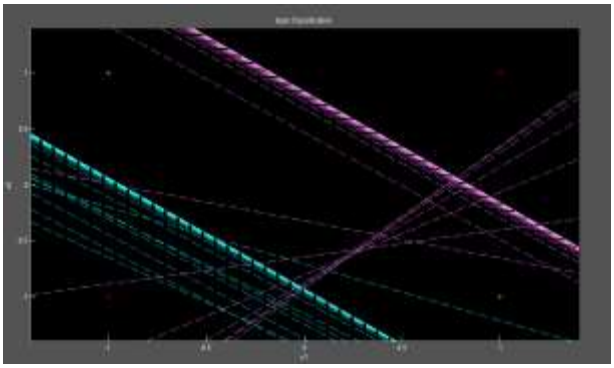


Fig. 6.6: Back Propagation Algorithm for the improvement of Thinning rate, MSE, PSNR

As shown in figure 6.6, to improve output of Zhang and Suen algorithm in terms of PNSR, MSE and TR enhancement is proposed which will be based on back propagation algorithm. In this figure, back propagation algorithm is executed with Zhang and Suen algorithm.

Fig. 6.7: New Thinned Image

As shown in figure 6.7, to improve output of Zhang and Suen algorithm in terms of PNSR, MSE and TR enhancement is proposed which will be based on back propagation algorithm. In this figure back propagation algorithm is executed with Zhang and Suen algorithm. After applying the back propagation algorithm the output of the thinning is image is shown in figure 6.7.

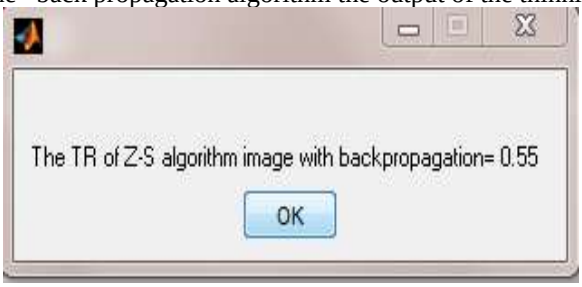


Fig. 6.8: Improved Thinning Rate

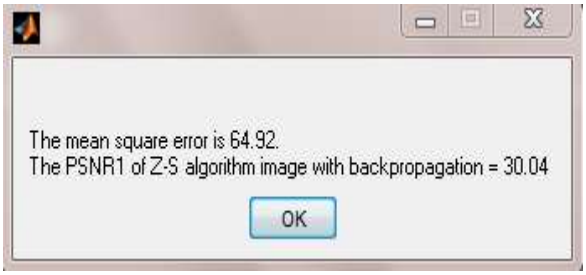


Fig. 6.9: Improved MSE, PSNR

As shown in figure 6.8 and 6.9, to improve output of Zhang and Suen algorithm in terms of PNSR, MSE and TR enhancement is proposed which will be based on back propagation algorithm. In this figure back propagation algorithm is executed with Zhang and Suen algorithm. After applying the back propagation algorithm the output of the thinning is image is shown which has better results than existing one. The results after applying MSE, PNSR and TR values are 64.92, 30.04 and 0.55 respectively.

VII. CONCLUSION

Thinning is technique which can remove unwanted pixels from the images. This technique is generally used to reduce the size of image. The technique of thinning is used over the compression because it cannot remove the wanted data from the image. In this work, Zhang and Suen algorithm for thinning has been reviewed and implemented. To apply thinning on the images, thinning elements has been selected which have white and black pixels. The white spaces which arise on the images are removed after combining with the thinning elements. The thinning algorithm's performance has been analyzed in terms of PSNR value, MSE value thinning rate. To improve performance of the algorithm enhancement has been proposed which is based on back

propagation algorithm. The simulation results shows that proposed algorithm performs batter in terms of PSNR, MSE and thinning rate. In future work, further improvement will be proposed in the enhancement and this enhancement will be based on Boltzman learning. The technique of Boltzman learning will improve thinning rate, PSNR and MSE value.

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