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A NOVEL EMBEDDED HYBRID THINNING ALGORITHM FOR IMAGE ENHANCEMENT AND ANALYSIS

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ABSTRACT

Image thinning is a morphological operation used in enhancing the image contrast. Edges of multiple pixel width are thinned to single pixel width .Many algorithms are proposed to thin images. Stentiford thinning algorithm and Zhan-Tsuen are two of them. This paper proposes a hybrid algorithm combining the above two algorithms. This hybrid approach is found to be more effective than the other two. Its efficiency is tested by comparing the result with those of the other two algorithms.

Keywords: Stentiford Thinning,zhang-suen thinning,Hybrid Thinning

1. INTRODUCTION

Digital images have been widely used in a growing number of applications and the effort to improve the images has been focused mostly to improve visual perception of images that are unclear because of a variety of reasons. Image processing is any form of signal processing for which the input is an image, such as photographs or frames of video; the output of image processing can be either an image or a set of characteristics or parameters related to the image[9].Digital image processing is the use of computer algorithms to perform image processing on digital images .As a sub field of digital signal processing, digital image processing has many advantages over analog image processing; it allows a much wider range of algorithms to be applied to the input data, and can avoid problems such as the build-up of noise and signal distortion during processing. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. Images can be processed by optical, photographic, and electronic means, but image processing using digital computers is the most common method because digital Methods are fast, flexible, and precise. Image enhancement improves the quality (clarity) of images for human viewing.

2. FUNDAMENTAL STEPS IN DIGITAL IMAGE PROCESSING

The fundamental steps in digital image processing involves many stages; image acquisition, enhancement, restoration, color image processing, wavelets, compression, morphological processing, segmentation, representa0tion and description as well as recognition. Every process need not be applied to an image. The intention is to convey an idea of all the methodologies that can be applied to images for different purposes and possibly with different objectives.

The steps involved in Digital Image processing are pictographically depicted as follow

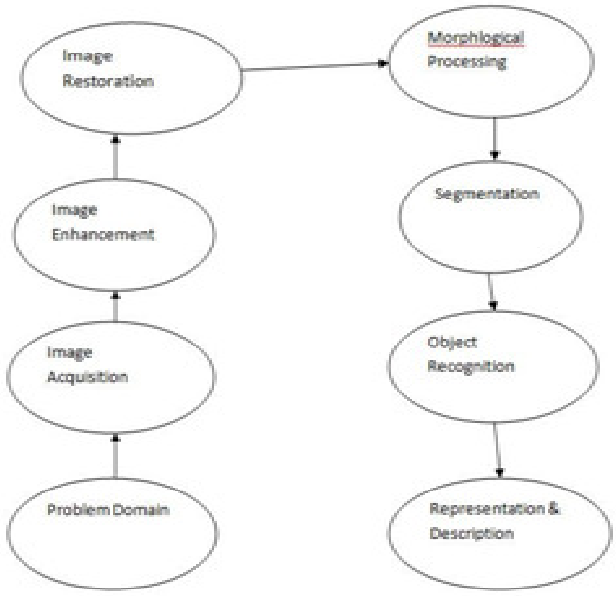

Figure 1 Key stages in Digital Image Processing

2.1 Morphology

The word *morphology* commonly denotes a branch of biology that deals with the form and structure of animals and plants. We use the same word here in the context of *mathematical morphology* as a tool for extracting image components that are useful in the representation and description of region shape, such as boundaries, skeletons, and the convex hull. The language of mathematical morphology is set theory. As such, morphology offers a unified and powerful approach to numerous image processing problems. Sets in mathematical morphology represent objects in an image. For example, the set of all black pixels in a binary image is a complete morphological description of the image. In binary images, the sets in question are members of the 2-D integer space Z^2, where each element of a set is a tuple (2-D vector) whose coordinates are the (x,y) coordinates of a black pixel in the image. Gray-scale digital images can be represented as sets whose components are in Z^3. In this case, two components of each element of the set refer to the coordinates of a pixel, and the third corresponds to its discrete gray-level value. Sets in higher dimensional spaces can contain other image attributes, such as color and time varying components.

2.3. Morphological Thinning

Thinning is a morphological operation that is used to remove selected foreground pixels from binary images, somewhat like erosion or opening. It can be used for several applications, but is particularly useful for skeletonization. In this mode it is commonly used to tidy up the output of edge detectors by reducing all lines to single pixel thickness. Thinning is normally only applied to binary images, and produces another binary image as output. Like other morphological operators, the behavior of the thinning operation is determined by a structuring element.

2.4. Thinning Methods

General

Thinning algorithms can be divided into two broad classes namely iterative and non-iterative. Although non-iterative algorithms can be faster than iterative algorithms they do not always produce accurate results.

Iterative Thinning

The Template-Based Mark-and-Delete Thinning Algorithms are very popular because of their reliability and effectiveness. This type of thinning processes uses templates, where a match of the template in the image, deletes the center pixel. They are iterative algorithms, which erodes the outer layers of pixel until no more layers can be removed [3]. Almost all iterative thinning algorithms use Mark-and-Delete templates including Stentiford Thinning Method.

Both Stentiford and Zhang-Suen methods use Connectivity numbers to mark and delete pixels.

2.5. Connectivity Number

The Connectivity number is a measure of how many objects are connected with a particular pixel. The following is the equation to calculate Connectivity number.

$$C_n = \sum_{k \in S} N_k - (N_k \cdot N_{k+1} \cdot N_{k+2})$$

Where: N_k is the colour of the eight neighbours of the pixel analyzed. N_0 is the center pixel. N_1 is the colour value of the pixel to the right of the central pixel and the rest are numbered in counter clockwise order around the center.

S = {1, 3, 5, 7}

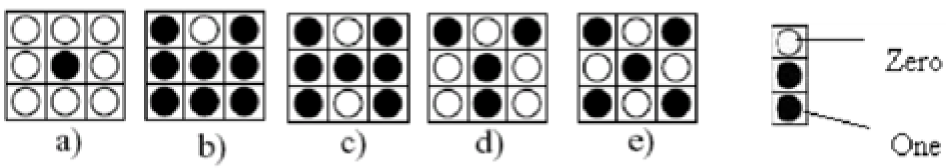

Figure 1

The following are the connectivity numbers for Figure 2.3.1:

- Connectivity number = 0.
- Connectivity number = 1.
- Connectivity number = 2.
- Connectivity number = 3.
- Connectivity number = 4.

2. 6. Stentiford Thinning Algorithm

It uses a set of four 3 x 3 templates to scan the image.

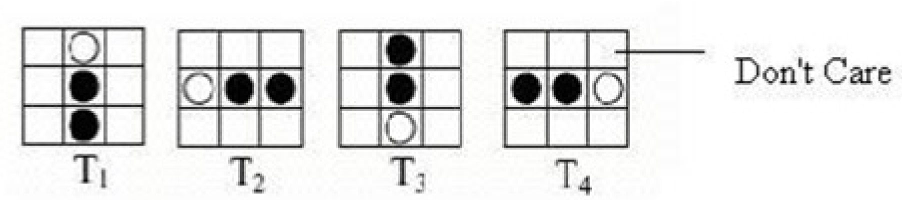

Figure 2 shows these four templates

The Stentiford Algorithm can be stated as following:

1. Find a pixel location (i, j) where the pixels in the image match those in template T1. With this template all pixels along the top of the image are removed moving from left to right and from top to bottom.
2. If the central pixel is not an endpoint, and has connectivity number = 1, then mark this pixel for deletion.

   Endpoint pixel: A pixel is considered an endpoint if it is connected to just one other pixel. That is, if a black pixel has only one black neighbour out of the eight possible neighbours.
3. Repeat steps 1 and 2 for all pixel locations matching T1.
4. Repeat steps 1-3 for the rest of the templates: T2, T3, and T4.

   T2 will match pixels on the left side of the object, moving from bottom to top and from left to right. T3 will select pixels along the bottom of the image and move from right to left and from bottom to top. T4 locates pixels on the right side of the object, moving from top to bottom and right to left.
5. Set to white the pixels marked for deletion.

Zhang-Suen Thinning Algorithm

This skeletonization algorithm is a parallel method that means the new value obtained only depend on the previous iteration value. It is fast and simple to be implemented. This algorithm is made by two sub-iterations. In the fist one, a pixel I (i , j) is deleted if the following conditions are satisfied [3]:

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 sub-iteration the conditions in steps 3 and 4 change.

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.

At the end, pixels satisfying these conditions will be deleted. If at the end of either sub-iteration there are no pixels to be deleted, then the algorithm stops.[15]

Hybrid Thinning Algorithm

This algorithm is made by two sub iterations. In the first one, a pixel I(i,j) is deleted if the following condition are satisfied.

1. Its connectivity number is one.
2. It has at least two black neighbors and not more than six.
3. At least one of T4, T1, T2 matches.
4. At least one of T1, T3, T2 matches.

In the second iteration

1. Its connectivity number is one.
2. It has at least two black neighbors and not more than six.
3. At least one of T1,T4,T3 matches.
4. At least one of T4,T3,T2 matches.

Analysis

An input image is thinned using stentiford thinning algorithm, Zhuan-Tsuen thinning algorithm and then the proposed hybrid thinning algorithm.The results are shown below.

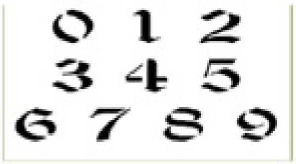

Fig:a

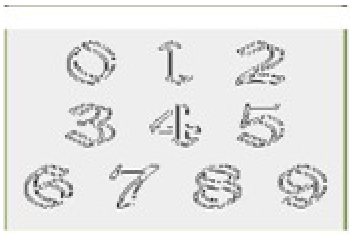

Fig:b

Fig:c

Fig:d

a:Input image

b:Output of Zhuan-Tsuen thinning algorithm

c:Output of Stentiford thinning algorithm

d:Output of Hybrid thinning algorithm

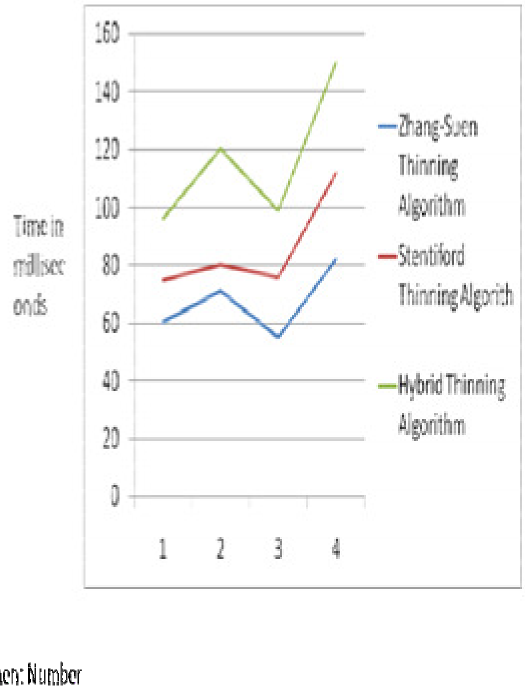

Figure 3 Comparison of Time complexity of the three Algorithms

Hybrid approach is found to be having more time-complexity than the other two.But it is more accurate. The results show that hybrid thinning algorithm is more effective in increasing the contrast of the image.

3. CONCLUSION

This paper proposed a new hybrid morphological thinning algorithm. Experimental results show that it is more accurate in thinning the image.However it does not show any improvement regarding the time complexity.Future research can envisage to improve time performance**.**

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