بسم الله الرحمن الرحيم

شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم

شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الالكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها

علي هذه الأفلام قد أعدت دون أية تغيرات

يجب أن

تحفظ هذه الأفلام بعيدا عن الغبار

في درجة حرارة من ١٥-٢٥ مئوية ورطوبة نسبية من ٢٠-٤٠%

To be Kept away from Dust in Dry Cool place of 15-25- c and relative humidity 20-40%

بعض الوثائـــــق الاصليـــة تالفـــة

بالرسالة صفحات لم ترد بالاصل

A New Parallel Thinning Algorithm For Gray Scale Images

A Thesis Submitted to the Faculty of Science,
Cairo University in Fullfilment of the
Requirements for the Degree of Ph.D. in

Computer Science

By

Samira Saad Mohamed Mersal

Supervisors

Prof. Laila M. Abd Elaal
Mathematics Department
Faculty of Science
Cairo University

Prof. Ahmed M. Darwish
Computer Engineering Department
Faculty of Engineering
Cairo University

Faculty of Science
Cairo University
2000

Abstract

A new parallel thinning algorithm for gray scale images is proposed. The algorithm is based on repeated application of removal operation which erodes gray scale image until only a one pixel thick subset is obtained. The removing operation is applied to all pixels in the image in parallel. A small neighborhood binarization is considered for every pixel. The set of pixels which satisfy certain conditions is removed. The conditions guarantee that the resulting thinned version is connected. Two types of removal operations are considered . Restricted removal and unrestricted removal to guarantee that the resulting thinned version is located along the center of the ridges where they exist. The algorithm can process simple gray scale images (images do not contain hollows surrounded by ridge lines) as well as images that contain hollows. A hollow at elevation k is a flat region such that a path from any pixel in the region to a pixel not in the region must include at least one pixel having a value greater than k. Thinning images which contain hollows are accomplished by using a hollow detection procedure which converts an interior pixel into a border pixel so as to render it a candidiate for removal. The algorithm was tested using three groups of images, 40 chromosomes images, 24 actinomyces images and 6 text and graph like images. Different tuning parameters were used in the tests. These parameters are the number of smoothing iterations, the percentage of edge pixels used in the hollow detection procedure, the type of removal operation which may be restricted or unrestricted and whether the image is segmented (into background with zero value and objects with positive value) or not. The results showed that with the proper selection of the tuning parameters the algorithm is a powerful tool that could be used for image analysis applications.

اعوذ باللـــه من الشيطان الرجيم

" رب اوزعني ان اشكر نعمتك التي انعمت عليّ
وعلى والدي وان اعمل صالحاً ترضاه وأصلح لي في ذريتي
اني تبت اليك واني من المسلمين "

Acknowledgement

Aknowledgement

I am happy to take this opportunity to thank many people who helped me during the preparation of this thesis.

I would like to express my appreciation, gratitude and thanks to Dr. Ahmed M. Darwish , Professor of Computer Engineering for his helpful guidance, illuminating remarks, encouragement and kind supervision of this thesis. I am really indebted to him.

My deepest gratitude and thanks go to Dr. Laila M. Abd Elaal, Professor of Mathematics for her encouragement, support and valuable advice.

I would also like to thank Dr. Yomin M. Mobarak, Lecturer at Zoology Department, Faculty of Science, Suez Canal University for his help in providing me with mice chromosomes images.

And finally no words are enough to thank my family for their generosity, patience, warmth and love.

Contents

Chapter 1: Introduction

1.1 Motivation and Justification 1

1.2 Thinning and Skeletonization 2

1.3 Problem Definition and Summary of Approach 5

1.4 Thesis Overview 6

Chapter 2: Thinning Algorithms for Binary Images

2.1 Introduction 7

2.2 Algorithms Described Using Mathematical Morphology Operations 7

2.2.1 Mathematical Morphology 7

2.2.1.1 Hit miss transformation 8

2.2.1.2 Erosion 8

2.2.1.3 Dilation 9

2.2.1.4 Opening and closing 9

2.2.2 Sample Algorithms 10

2.3 Algorithms Based on Neighborhood Criteria 14

2.3.1 Notions and Definitions 15

2.3.2 Algorithms Based on Repeated Object Pixel Removal 18

2.3.2.1 Sequential algorithms 18

2.3.2.1.1 Raster scan algorithms 19

2.3.2.1.2 Contour following algorithms 19

2.3.2.2 Parallel thinning algorithms 23

2.3.2.2.1 Four subcycles parallel thinning algorithms 23

2.3.2.2.2 Two subcycles parallel thinning algorithms 26

2.3.2.2.3 Fully (one subcycle) parallel thinning algorithms 30

2.3.3 Algorithms Based on the Contour of The Object 36

2.3.4 Algorithms Based on Distance Transformation 38

2.4 Conclusion 50

Chapter 3: Gray Scale and 3D Thinning Algorithms

3.1 Introduction 52

3.2 Algorithms Described Using Gray Scale Mathematical Morphology 53

3.2.1 Gray Scale Mathematical Morphology 53

3.2.1.1 Gray scale erosion 53

3.3.1.2 Gray scale dilation 54

3.2.1.3 Gray scale opening and closing 56

3.2.2 Sample Algorithms 56

3.3 Algorithms Based on Neighborhood Criteria 58

3.4 3D Thinning Algorithms 64

Chapter 4: A New Parallel Thinning Algorithm for Gray Scale Images

4.1 Introduction 66

4.2 Definitions 66

4.3 Algorithm 67

4.3.1 Preprocessing 69

4.3.1.1 Segmentation 69

4.3.1.2 Smoothing 69

4.3.1.3 Hollow detection 69

4.3.2 Removal Operation 70

4.3.2.1 Unrestricted removal operation 71

4.3.2.2 Restricted removal operation 72

4.3.3 Pruning 73

4.4 Summary of The Algorithm 74

4.5 Analysis of Tuning Parameters 75

4.6 Proof of the Termination of The Algorithm 90

4.7 Computational Complexity 91

Chapter 5: Results

5.1 Introduction 92

5.2 Test Set 92

5.2.1 Test Set One: Chromosomes Images 92

5.2.2 Test Set Two: Actinomyces Images 98

5.2.3 Test Set Three: Documents and Engineering Drawing 106

5.3 Results Analysis 106

5.3.1 Test Set 1 106

5.3.2 Test Set 2 141

5.3.3 Test Set 3 144

Chapter 6: Conclusion and Future Work 149

References 151

Chapter 1

Introduction

Chapter 1

Introduction

1.1 Motivation and Justification

The use of a data reduction technique is essential whenever the amount of data at disposal is large with respect to the real needs of the task to be executed. Thinning is such an example in image processing. It is a fundamental preprocessing step for several pattern recognition algorithms and analysis applications. The use of thinning span a wide range of applications. In the biomedical field, applications of thinning include analysis of chromosomes and x-ray image analysis of coronary arteries. In other fields, thinned images have found applications in the processing of bubble chamber negatives, recognition of typed and handwritten text, counting of asbestos fibers in air filters, quantitative metallography, measurements of soil cracking and automatic visual analysis of industrial parts [12, 33, 53, 89].

The wide range of applications shows the usefulness of thinning, which reduces patterns to thin line representations. The thin line representation of certain elongated patterns permits a simpler structural analysis and more intuitive design of recognition algorithms. In addition, the reduction of an image to its essentials can eliminate some contour distortions while retaining significant topological and geometric properties.

Applying thinning directly to gray scale images is motivated by the desire to directly process images with gray scale levels distributed over a range of intensity values. This will avoids shape distortions that may irremediably affect the presence of features in the binary image generated even if an optimal thresholding algorithm is used to produce the binary image. The thinned version obtained from thinning a gray scale image algorithm after thresholding is dependent on the chosen threshold value, so thinning gray scale images directly is preferred.

1.2 Thinning and Skeletonization

Thinning and skeletonization have been intensively investigated in the literature. Several researchers have used different definitions of skeletons. Some of these definitions documented in the literature will be listed in the following according to the similarity in handling.

Blum[14] and Montanari [64] defined the skeleton as the result of propagating wave fronts from the inside of the edge of the figure. The skeleton is then the locus of the intersection of wavefronts from opposite sides. This definition is equivalent to the definition by Duda and Hart [26]. They imagine the interior of the figure to be composed of dry grass and suppose a fire is set simultaneously at all points along the figure boundary. The fire propagates with a uniform speed towards the middle of the figure. At some points the fire fronts from various directions are meet. These points are called quench points. The set of quench points defines the skeleton of Fig. (1.1) illustrates the fire propagation concept.

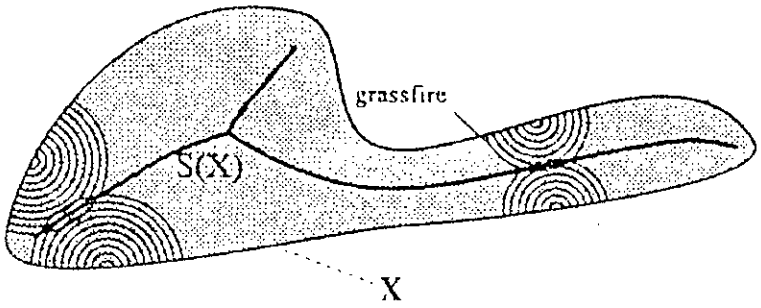

Figure 1.1 An illustration of the fire propagation concept.

Consider the following two simple examples. If the figure is a circle then the advancing fire line will describe concentric circles of continuously decreasing radius until the fire is extinguished at the center of the circle. In this case the skeleton is a single point. A second example is a rectangle. The advancing fire line, initially is also a rectangular and adjacent sides extinguish each other forming branches a, b, c and d of the skeleton. At the instant that these branches are complete the short sides of the fire