Computer Science Department
Faculty of Computer and Information Science
Ain Shams University

Parallel Processing for Digital Image Enhancement

A thesis submitted in partial fulfillment of the requirements for the degree of
Master of Science
In
Computer and Information Sciences
By

Nora Youssef Fahmy Abd El-Mageed Youssef

B.Sc. in Computer and Information Sciences,
Teaching assistant at Computer Science Department,
Faculty of Computer and Information Sciences,
Ain Shams University.

Under the Supervision of

Prof. Dr. El-Sayed M. El-Horbaty

Prof. of Computer Science,
Head of Computer Science Department,
Faculty of Computer and Information Sciences,
Ain Shams University.

Dr. Abeer M. Mahmoud

Lecturer of Computer Science,
Department of Computer Science, Faculty of Computer and Information Sciences,
Ain Shams University.

Acknowledgment

All praise and thanks to ALLAH, who provided me the ability to complete this work.

I have to thank my research supervisors, Prof. El-Sayed M. El-Horbaty and Dr. Abeer Mahmoud. Without their assistance and dedicated involvement in every step throughout the process, this thesis would have never been accomplished. I would like to thank you very much for your support.

I am deeply thankful for my family for their care and prayers, specially my mother; I would be nothing without you Mom. All my thanks to my friends; for their support and encouragement.

I would never forget the supporters, L.A. Mahmoud Hossam, L.A. Mahmoud Fayez, Eng.Mahmoud Khalifa, L.A. Ahmed Salah, Dr.Wael Hamdy, Dr, Salama Hamdy & L.A. Maryem Al-Berry, Thank you all for your care and support.

Abstract

Image De-noising is a subfield of image enhancement in general, which it focuses on the removal of any undesired details that corrupts the digital image. Actually, this can be achieved through various filtering techniques, where the variation is compared on a base of enhancement parameters and the keep of sensitive and important details. On the other hand, medical imaging is the technique used to create images of the human body or parts of it for clinical purposes. Medical images always have large sizes and they are commonly corrupted by single or multiple noise type at the same time, due to various reasons, these two reasons are the triggers for moving toward parallel image processing to find alternatives of image de-noising techniques.

This thesis proposes hybrid de-noising approach that is based on adaptive median filter in the spatial domain followed by wiener filter in the Fourier transform domain for the removal of circular blurredness, Gaussian and impulse additive noises simultaneously. The proposed de-nosing approach is tested on a data set of gray scale medical images or Digital Imaging and Communications in Medicine (DICOM), each of which was corrupted by additive Gaussian noise with variance 0.05 and Salt & pepper with probability 0.2. Moreover, we analyze the hybrid de-noising approach in terms of peak signal to noise ratio (PSNR) for image quality assessment. The results showed that the proposed hybrid approach recorded higher PSNR 19.8 dB compared to the standalone adaptive median or wiener filters.

In addition, a parallel hybrid filter algorithm is also proposed for gray scale medical image de-noising. The hybridization is between adaptive median and wiener filters. Parallelization is applied on the adaptive median filter to overcome the latency of neighborhood operation, parfor implicit parallelism powered by MATALAB 2013a is used. The algorithm is tested on an image of 2.5 MB size, which is divided into 2, 4 and 8 partitions; a comparison between the proposed algorithm and sequential one is given, in terms of time. Thus, each case has the best time when assigned to number of threads equal to the number of its partitions. Moreover, Speed up and efficiency are calculated for the algorithm and they record a measured enhancement.

Contents

List of Figures

List of Tables

List of Publications

1. Nora Youssef, Abeer M. Mahmoud and EL-Sayed M. EL-Horbaty "A Parallel Hybrid Technique for Multi-Noise Removal from Grayscale Medical Images" Int. J Real Time Image Processing, Springer, Berlin, IF 1.11, May 2015 (Submitted)

2. Nora Youssef, Abeer M. Mahmoud and EL-Sayed M. EL-Horbaty "Gaussian De-Noising Techniques" (Book Chapter) Lambert Academic Publishing, Germany, Apr. 2015.

3. Nora Youssef, Abeer M. Mahmoud and EL-Sayed M. EL-Horbaty "A Hybrid De-Noising Technique for Multi-noise Removal on Gray Scale Medical Images", Int. J. of Tomography and Simulation (IJTS) IF 0.75, Vol. 28, No.2, pp 106-116, India, Mar. 2015.

4. Nora Youssef, Abeer M. Mahmoud and EL-Sayed M. EL-Horbaty "Gaussian De-Noising Techniques in Spatial Domain for Gray Scale Medical Images", Int. J. of Information Technologies and Knowledge (ITK), Vol. 8, No.3, pp.90-100, Bulgaria**,** Jun. 2014.

Chapter 1. Introduction

Introduction

Image de-noising is a challenging process in digital image enhancement aiming at the removal of noise and is still a demanding problem for researchers. During acquisition and transmission, images are often corrupted and de-noising is an essential step to improve the image quality [1]. For example, linear techniques are used to remove Gaussian noise, and order statistics techniques are used to remove impulsive noise. Hybrid filters have been developed to remove either Gaussian or impulsive noise. There are filters available which can remove either only single type or mixed types of noise from the images simultaneously [2].

Image Processing with parallel computing is an alternative way to solve image processing problems that require large time of processing or handling large amounts of information in acceptable time [3]. In parallel processing, a program is able to create multiple tasks that run together to solve a problem. The main idea of parallel image processing is to divide the problem into simple tasks and solve them concurrently, in such a way the total time can be reduced. There are different parallel processing decomposition techniques like functional and data decomposition.

There are many tools supporting the parallel image processing, MATALAB 2013a onwards finally enables the "Parallel Computation Toolbox" for student use. It's not part of the core MATALAB student package, but it is now available as an add-on toolbox. Of course, it has been available for commercial users for some time [4]. As well as many tools like, OpenMP, MPI, DirectCompute, CUDA, C++ AMD and OpenCL can be used.

This thesis shows a comparative study for Gaussian de-noising spatial techniques, and then an upgrade for a hybrid sequential technique for Gaussian, salt & pepper and circular blur elimination, finally an enhancement in terms of time performance for the pervious sequential techniques by using data parallelization as a decomposition model.

1.1 Problem Definition

Image enhancement and restoration in a noisy environment are fundamental problems in image processing. Various filtering techniques have been developed to suppress noise in order to improve the quality of images. Many filters for image processing were designed assuming a specific noise distribution. For example, linear techniques are used to remove

Gaussian noise, and order statistic techniques are used to remove impulsive noise. Practically speaking, images are corrupted by multi-noise type (i.e. Gaussian, salt & pepper and blur) at the same time. Thus, there is an open demand for multi-noise removal filters.

Medical imaging is the mechanism, which is used to create images of internal structure of the human body, for clinical or medical purposes. There are different medical image forms examples, like CT, PET, and MRI etc. These forms have different characteristics and used as per requirements. One of these characteristics is that these modalities have very large size, so processing these forms take so much time when using sequential manner, so, we have to parallelize the traditional sequential algorithms for the sake of time performance improvement.

1.2 Objectives

The objectives of the thesis are to:

1. Develop sequential hybrid de-noising filter and show that it is better than simple filters for multi-noise removal in terms of peak signal to noise ratio.
2. Develop parallel hybrid de-noising filter and show that it is better than the sequential hybrid in terms of time
3. Give an overview of the literature work.

1.3 Thesis Outlines

The rest of this thesis is organized as follows: Chapter 2: Gives the background needed in both digital image processing and parallel processing. Chapter 3: Discusses the literature review and state a Gaussian de-noising elimination experiment. Chapter 4: Contains the proposed sequential algorithm architecture, implementation, gained results and discussion. Chapter 5: Introduces the parallel algorithm and the comparison between it and the pervious sequential algorithm. Finally, conclusions and future work are given in Chapter 6.

Chapter 2. Background & Related Work

Background & Related Work

In this chapter, we will highlight the visited fields in either digital image processing, or parallel processing. The next section will give an overview of digital image processing specially enhancement sub field. After it, an overview of parallel processing will be given. Then ending with a summary of the literature review.

2.1 Digital Image Processing

This sections gives an overview of digital image processing field, we will show what digital image, image enhancement and restoration, enhancement domains, noises, filters and the commonly used quality assessment metrics.

2.1.1 Digital Image

Digital image is defined as a two-dimensional function, *f(x, y)*, where *x* and *y* are spatial coordinates, and the amplitude of *f* at any point *(x, y)* is called the intensity or gray level of the image at that point, refer to Figure 2.1 for illustration. The field of digital image processing refers to processing of a digital image by means of digital computers. Today there is almost no area of technical endeavor that is not impacted in some way by digital image processing. There are enormous fields make the use of digital image processing and we can categorize them according to their source (Ultraviolet, Microwave band, Radio band, satellite imaging and so on) [5].

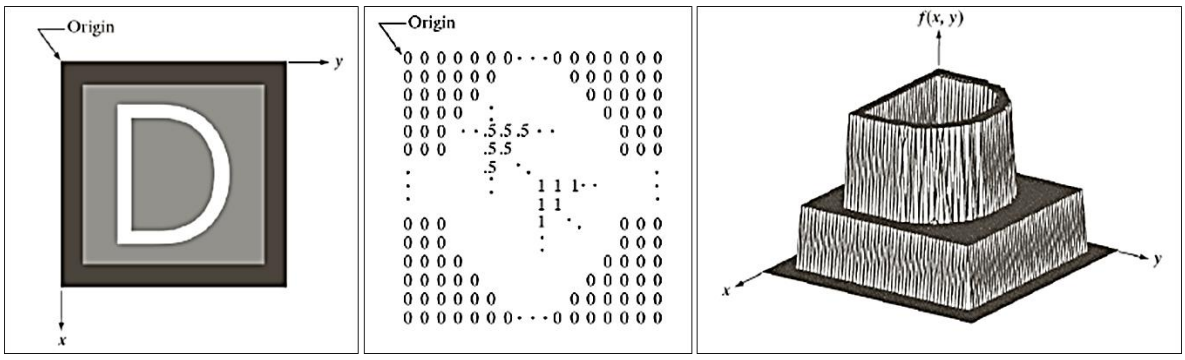

Figure 2.1: Intensity level representation. (a) Original gray scale image. (b) Pixel value representation and (c) 3D gray level representation

We can classify images based on its color info, so that we have three categories of images binary, gray scale and color images [6].

Binary images are the simplest type of images and can take only two discrete values, black and white. Black is represented with the value '0' while white with '1'. Note that a binary image is generally created from a gray-scale image. A binary image finds applications in computer vision areas where the general shape or outline information of the image is needed. They are also referred to as 1 bit/pixel images. Figure 2.2 is for an example.

Gray-scale images are known as monochrome or one-color images such as Figure 2.3. Images used for experimentation purposes in this thesis's images are all gray-scale. They contain no color information. They represent the brightness of the image. This image contains 8 bits/pixel data, which means, it can have up to 256 (0-255) different brightness levels. A '0' represents black and '255' denotes white. In between values from 1 to 254 represent the different gray levels. As they contain the intensity information, they are also referred to as intensity images.

Color images as in Figure 2.4 are considered as three band monochrome images, where each band is of a different color. Each band provides the brightness information of the corresponding spectral band. Typical color images are red, green and blue images and are also referred to as RGB images. This is a 24 bits/pixel image.

Figure 2.2: Binary image example

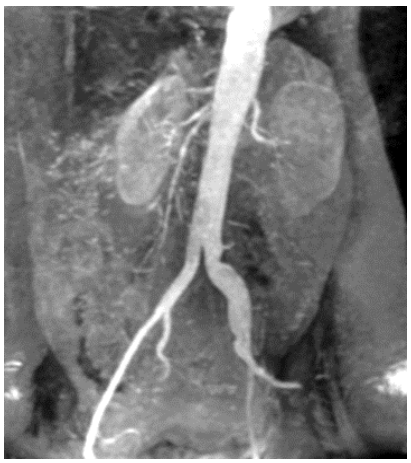

Figure 2.3: Gray scale example

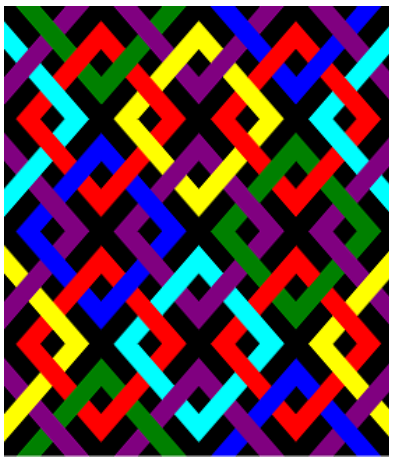

Figure 2.4: Colored image example

Medical Imaging is the technique and process used to create images of the human body (or parts and function thereof) for clinical or medical purposes. [3] In other words, it is process and art of creating visual representations of the interior of a body for clinical analysis and medical intervention. Medical imaging seeks to reveal internal structures hidden by the skin and bones, as well as to diagnose and treat disease [7]. There are so many different medical