Medical Image Denoising using Multi-resolution Wavelet Transform and Diffusion Filter

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DECLARATION OF THESIS

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LIST OF ABBREVIATION

SNR	Signal-to-Noise Ratio
PSNR	Peak Signal to Noise Ratio
AWGN	Additive White Gaussian Noise
DWT	Discrete Wavelet Transform
HVS	Human Visual System
LMMSE	Linear Minimum Mean Square-Error
MSE	Mean Squared Error
PDF	Probability Density Function
SSIM	Structure Similarity Index Metric
IQA	Image quality assessment

Denoising Imej Perubatan menggunakan multiresolusi Wavelet Transform dan Difusi Filter

ABSTRAK

Dalam projek ini Matlab akan menapis imej perubatan yang tidak diperlukan dengan menggunakan pelbagai resolusi ubahan wavelet dan penapis resapan. Imej perubatan yang tidak diperlukan ditapis daripada 'Gaussian Noise' dengan menggunakan algoritma daripada ubahan wavelet dan penapis resapan pada MATLAB dan menilai prestasi kedua-dua penapis dengan mengukur perbezaan di antara isyarat kepada nisbah bunyi, puncak-isyarat-kepada-hingar, punca purata ralat kuasa dua dan struktur indeks persamaan. Keluaran dari penapis wavelet sangat dekat dengan kualiti imej yang tinggi dan tidak ada kekaburan dalam imej keluaran. Walau bagaimanapun, keluaran dari penapis resapan adalah sangat bersih dari imej yang tidak diperlukan ditambah. Daripada keputusan itu boleh disimpulkan bahawa untuk 'Gaussian Noise', penyebaran sentiasa memberikan hasil yang lebih berkualiti, di mana ia memperolehi indeks persamaan struktur yang tinggi berbanding dengan ubahan wavelet penapis.

Medical Image Denoising using Multi-Resolution Wavelet Transform and Diffusion Filter

ABSTRACT

In this project medical image denoised by using proposed filter, multi-resolution wavelet transform and diffusion filter. Medical images denoised from Gaussian noise by applying the algorithms of wavelet transform and diffusion filter and both filter on Matlab and evaluate the performance of the three filters by measuring the difference between signal to noise ratio , peak-signal-to-noise ratio, root mean square error and structural similarity index. The output from wavelet filter is very close to the high quality image and there is no blurring in the output image and the output from diffusion filter was very clean from the added noise. However, the output from the proposed filter more clear than other filters and the result has the best result. From the results it can be deduced that for Gaussian noise, proposed filter always gives better quality result, where it obtained high structural similarity index compared to wavelet transform and diffusion filters.

CHAPTER 1

INTRODUCTION

1.1 Background

Digital images become the indispensable things in our life nowadays. While these images are being transferred or taken, they might be disrupted by a noise which is displayed in the form of a Gaussian. When reducing the noise in the image, the basic objective is to conserve the characteristics of the image along with reduction in the noise. Noise reduction is an issue that has occurred in image processing in the past and still this problem exists. The techniques used for the reduction of noise in the image are time and frequency domain processing techniques. Using the frequency domain method the noise signal is converted into a frequency domain and then the frequency coefficients are used for overpowering the noisy signal before it is converted back into the three dimensional domain. The most frequently used techniques in the frequency domain methods are Wavelet-based techniques. Moreover, wavelets have the ability to efficiently catch the zero dimensional individuality but they are incapable of capturing the demonstration of one dimensional discontinuity e.g. the boundaries and bends in an image are present because they are incapable of absorbing light (Ruikar & Doye, 2011). Therefore, diffusion filter is proposed beside wavelet transform to overcome this problem.

1.1.1 Wavelet Transform

A basic problem in processing a signal is the identification of an appropriate demonstration of the data that will make the analysis procedure easier. Making use of the disintegrated signal on a range of basic functions before processing it in the transform domain is a way to achieve this objective. For many years, transform theory has performed a vital part in the field of image processing, and has remained an interesting subject in the academic and practical work that involves image enhancement, restoration, encoding, description and many other image processing fields make use of image transforms on a large scale. Those characteristics of wavelet transform make the denoising of less degraded image more convenient (Bao & Lie, 2003). The basic objective of using this technique is to make the noised areas smooth with affecting other areas.

1.1.2 The Advantages of Wavelet Transform

1- The ability to compact most of the signals energy into a few transformation coefficients which is called energy compaction.

2- Effective capturing and demonstration of components with low frequency and high frequency transients.

3- The ability to disintegrate variety of resolutions with nearly uncorrelated coefficients.

1.1.3 Diffusion Filter

Diffusion filter has been able to gain popularity and take important advancements with effective outcomes and applicability in variety of peculiar fields.

The unique characteristic of the technique is that it decreases the unnecessary intensity variability from the objects in the image with the loss of minimum information and makes the contrast of the boundaries more prominent (Liu, 2009).

1.1.4 Image Enhancement

For the achievement of visually suitable images and change of images, a wide range of concepts are offered by image enhancement algorithms. The selection of these techniques is a function of the definite task, image content, features of the viewer, and viewing circumstances. The most traditional and still most important methods for contrast enhancement are the point processing methods. For use in medical images and for making white details inside dark areas prominent Image Negative is most suitable. For management of contrast for ordinary purpose power-law transformations are appropriate. With the use of power-law transformation with a fractional exponent the grey levels can be widened (Maini, & Aggarwal, 2010). For increasing the fine points in the darker areas of the image by decreasing the fine points in the brighter regions where values are high, log transformation is used. For an image which has wasted look, Gray levels are compressed with the use of a power-law transformation with γ greater than 1. Information about the contrast of the image is provided efficiently with the use of a histogram. Stretching of the contrast with the help of equal distribution of grey level values is done through histogram equalization. The complete automatic equalization of the global histogram is the only thing that can be done.

1.1.5 Measurement of Image Quality

For various applications that are used for image processing, assessment of image quality is important. The examination of quality of the image is almost similar to the examination of similarity of the image in which the basis of quality is the differences(or similarities)between the actual image and the image which has noise in it. Using the examination of image quality there are two methods that can help us assess quality of the image.

While assessing quality of the image subjectively, human eye is considered to be the best instrument. It is based on the perception of an individual i.e. the way he sees the object. This assessment is most of the ties slow and costly and is very complicated to be repeated or checked for verification. Hence, in recent years objective methods of assessment have gained popularity. A mathematical model objective quality assessment produces results that are almost similar to the results obtained through subjective measures for the measurement of image quality. The basic objective to use this method is to get measurement in terms of quantities which can then asses the observed quality of the image (Maini & Aggarwal, 2010). It has many functions such as, controlling the quality of the image so that it can be useful for quality control systems, to create standards for image processing systems and to adjust algorithms and limitations.

1.2 Problem Statement and Motivation

Image denoising is a procedure in digital image processing trying to eliminate noise, which might make the image shady while it is being transferred or taken, conserving its quality at the same time. Noise harms the visual quality of the image and also decreases the appearance of objects which have a low contrast. People who have

experience in this field are aware of the fact that making an image noise free along with conservation of its quality is a very difficult task to achieve most importantly when the minor details or hidden structures are to be made prominent. While making the design of any new filter the two contrasting goals of noise reduction and conservation of details are very difficult to achieve.

Noise reduction within an image with wavelet transform becomes the interested area of research for the recent years. Furthermore, the characteristics of wavelet modification make it very suitable for the noise reduction in images along with conservation of its quality. The basic objective behind the use of wavelet for noise reduction is that they have the ability to make some areas with noise and do not affect other areas (Ruikar & Doye, 2011). Diffusion filter is another technique that has gained a lot of popularity and convincing results and can be employed in a variety of peculiar domains. This technique has the unique ability to decrease the unwanted intensity variability within the images with the loss of minimum information and make the contrast of the boundaries prominent. Some filters results in blurring effect and some results in reducing the data of the images while these data are one of the interests therefore, for measurement of the quality of the image and evaluation of the filtering algorithm, quality examination is required. The objective of the examination of the quality of the image is determination of a process which will measure the extent of similarity lies among the reference image and the image which has been denoised. Approaches like error sensitivity approach and observation process and a lot of others have been considered by practitioners. For the evaluation of images in this project various methods will be applied for the examination of quality of the image for instance, Signal-to-noise ratio (SNR), peak-signal-to-noise ratio (PSNR), mean squared error

(MSE) and structural similarity index metric (SSIM) after applying wavelet transform and diffusion filter on denoising medical images.

Medical image carried very useful information that and it is used for diagnosis purpose. In designing any new filter, two most contrasting problems are reducing the noise along with conservation of image quality. Furthermore, smoothing few areas while not affecting other areas is considering another challenge. Some filters has been design for removing noise; yet there is no enough evident that these algorithms are efficient in removing the noise with less degrade to the original image, as a result performance evaluation is very necessary to evaluate the filter in removing noise.

1.3 Aim and Objectives

The aim of this project is Medical image denoising using multi-resolution wavelet transform and diffusion filter reduce the noise and enhanced the medical image. The objectives of this thesis are:

- To denoised medical images with wavelet transform and diffusion filter and both together using matlab.
- To verify and evaluate the performance of wavelet and diffusion filtering in removing noise from medical images by using SNR, PSNR, MSE, and SSIM.
- To validate and compare the performance with wavelet transform, diffusion filter and both together.

1.4 Scope of Study

The project will starts from collecting database (medical images),applying filtering algorithm by wavelet transform, diffusion filter and both together. Performing quality evaluation of the three filters on the denoised images and finally validates which filtering algorithm work better. It can be concluded that, the project is limited to the use of wavelet and diffusion filters plus the used of image assessments methods for evaluation purpose.

1.5 Organization of Thesis

This thesis organized with five chapters and the contents of each chapter are as follows:

Chapter 1 elucidates the problem statement, background of the topic, motivation for this research, objectives and brief research methodology alongside this chapter cover the organization of this thesis.

Chapter 2 literature review brief introduction to medical imaging and type of noise. This chapter will introduces also the image enhancement methods and discusses the image denoising filters.

Chapter 3 methodology this chapter will introduces two methods for denoising medical images and compares their performance with several image quality assessment methods. Multi resolution wavelet transform and non-linear diffusion filter are the two algorithms proposed in this project for denoising medical images.

Chapter 4 results in this chapter will show the result and will explain it in detail.

Chapter 5 Conclusion this chapter will conclude the research finding with the recommendation of future work.

CHAPTER 2

LITERATURE REVIEW

In this chapter computerized imaging system is introduced and its working is explained. Types of noise and introduction to medical imaging are also explained briefly. This chapter introduces the methods by which image can be enhanced and also tells the characteristics of the denoising filters. Moreover it also explains the idea of wavelet transform and explains the sense of multiresolution wavelet transform filter. A discussion has been including related to the previously done work by wavelet and diffusion and a summary has been provided of the previously done work.

2.1 Introduction to Computerized Imaging System

A block diagram of the fundamental constituents of imaging system has been shown in the following diagram, whose functions are controlled by a computer. Four categories can be allotted to the functioning of such a system: Acquisition, Digitization, Processing and Display.

In the procedure of acquisition, a scintillation camera, the gantry of a CT scan or MRI unit or the probe of the ultrasound unit can be used as an instrument for the collection of data.

Digitization process: This process converts the analogue signal into the computer friendly digital form.

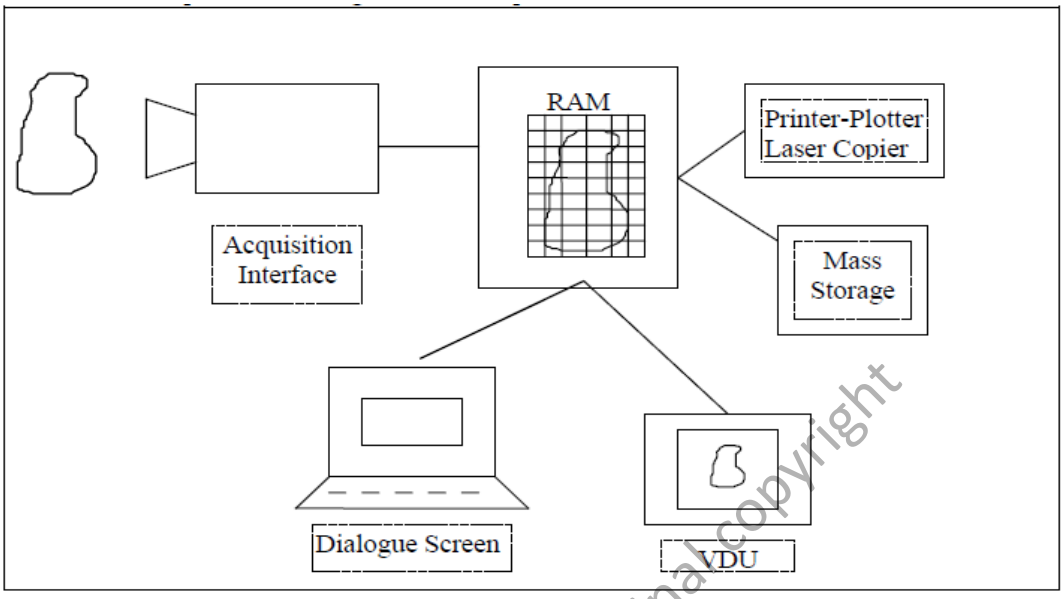

Figure 2.1: Computerized Imaging System

Processing: The operation of data processing is performed by the computer and the associated devices which are made for the purpose of making the process faster

2.2 Introduction and Overview of Medical Image Noise

Except for where the images brightness is modified into an image it is generally acceptable that it remains uniform. Even in the absence of details of the image still there are factors that affect the brightness of an image and cause changes in it. But this change is generally haphazard and does not have a routine form. In most of the cases, the quality of the image is affected by it, especially when the objects, whose image is being taken, are small in size and exhibit low contrast. This haphazard change in the brightness of the image is referred as noise.

Visual noise is present in almost all medical images. In the presence of noise the image looks mottled, grainy, textured, or snowy .We shall very soon find out the

reasons which cause noise. No method is completely free from noise but the difference is in the level of noise that is present in each method.

2.3 Image Noise Categories

Noise is unacceptable, no matter it is of what type and what characteristics. The categorization of noise is made on the basis of probabilistic specifications. This section explains the most common types of noise that spoil the images during the process of transferring them or acquiring them.

A. Gaussian noise This is the most commonly occurring type of noise. This kind of noise has a probability density function (PDF) of the normal distribution (also known as Gaussian distribution). Previous researchers have described it as additive white Gaussian noise (AWGN) because it is present as additional noise. In view of the probability density function equation Gaussian noise creates a noise sequence having a Gaussian normal distribution function.

B. Poison noise The non-linear response of the detectors and recorders become the cause of poison noise. This type of noise depends upon the data of the image. The emission of haphazard electrons with a Poisson distribution with a mean response value causes this noise. The image dependent term has a standard deviation because of the equality between the mean and variance of a Poisson distribution.

C. Speckle Noise The entire medical B-mode ultrasonic images exhibit this kind of noise and it is not acceptable because it hides relatively important features of the image from diagnosis point of view. Generally the data drop out noise is given the name of speckle noise. Literature suggests that this noise occurs because of faulty data transmission. The spoiled pixels in this case are attributed a high value which can be