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Research Article

Optimizing Wavelet based Medical Image De-Noising

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Abstract

Application of image processing in the area of medical sciences have revolutionized the diagnosis and treatment procedure. X-rays and ultrasound are considered to be the basic diagnosis tools in medical science. With the introduction of imaging in medical science, a great opportunity of research started in this area. New and advance algorithms are developed day by day to improve the quality of service these techniques give. An area of image restoration by denoising is also a field. Different algorithms are present to denoise an image corrupted by noise. In this paper we present a technique to optimize the denoising method using wavelets. Denoising in wavelet transform is controlled by threshold and level of decomposition. Here in this paper we present an analysis to determine the best suitable parameter of algorithm for implementation of wavelets. The main aim of image de-noising techniques is to remove noise while retaining as much as possible the important detail features. At the end we will discuss how de-noising techniques can be optimized using the thresholding parameter and varying the levels of decomposition.

Keywords: *De-noising, wavelets, image processing, decomposition, thresholding*

1. Introduction

Image processing is playing an important part in medical science. These techniques are the reliable diagnosis tools in medical sciences. It is used for detecting cracks in bones and soft tissues in organs like liver, kidney, spleen, uterus, heart, brain etc. These methods of diagnosis are widely acceptable because they are inexpensive, harmless to human body, portable and non–invasive. Another advantage of these techniques is that these are very fast. Generally medical images are affected by Gaussian noise. Addition of noise degrades the quality of image and affects decision in proper diagnosis. Different techniques are in practice to de-noise the medical images. These techniques use different algorithms to remove the noise introduced in the image. Wavelet based de-noising is commonly used for de-noising purpose (Ivana Duskunovic *et al*, 2000). The DWT is very efficient from a computational point of view, but it is shift variant. Therefore, its de-noising performance can change drastically if the starting position of the signal is shifted. An adaptive threshold for wavelet thresholding images was proposed, based on the GGD modeling of sub band coefficients, and test results showed excellent performance (S. Grace *et a*l, 2000) Another new spatially adaptive wavelet-based method in order to reduce the speckle noise from ultrasound images. Spatially adaptive threshold is introduced for de-noising the coefficients of log-transformed ultrasound images. The emphasis for using the wavelet transform is that it is good for energy compaction since the small and large coefficients are more likely to noise and important image features, respectively (M. Jansen *et al*, 2001). The wavelet-based denoising for the recovery of signal contaminated by white additive Gaussian noise and investigated the noise free reconstruction property of universal threshold (Yansun Xu *et al*, 1994). There have been many works on finding suitable thresholds; however, very few have been designed for images (D. L. Donoho *et al*, 1994; Quan Pan *et al*, 1999). There exist various methods for wavelet thresholding which rely on the choice of a threshold value such as Visu Shrink, Sure Shrink (X. P. Zhang *et al,* 1998; Ali Samir *et al*, 2006) and Bayes Shrink (S. G. Chang *et al*, 2000). Time and frequency localization is simultaneously provided by Wavelet transform. Moreover, wavelet methods represent such signals much more efficiently than either the original domain or Fourier transform (S. Arivazhagan *et al*, 2007). Optimization the de-noising process by selecting appropriate decomposition level and threshold in wavelet based method for ultrasound and x-ray imaging (X. Y. Wang *et al*, 2010). The source of noise responsible for image quality degradation in medical image is Gaussian, speckle and salt-and-pepper noise. Image de-noising still remains the challenge for researchers because noise removal causes blurring of the images and other unwanted operations (Idan Ram *et al*, 2011). Noise is undesired

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information that contaminates the image. It can happen due to certain spikes in the signal that are due to electrical fluctuations and disturbances that rise while the image is being taken. In medical imaging, particularly diagnosis where texture of the object in image should be clearly visible and not messy, noise has its adverse effects on detail. Texture depends on how noise is filtered from the image. If the texture is degraded, the image cannot be used for diagnosis. Texture details should be retained and considered while de-noising the images. The proposed de-noising method for medical images is using wavelets. In x-ray and ultrasound images, the noise can restrain information which is valuable for the general diagnosis. As a result medical images have become inconsistent and it is therefore necessary to operate case to case.

2. Methodology

In medical images like x-ray, ultrasound etc. information retrieval is directly proportional to the level of texture information. Wavelets operate on an image by smoothing process. When wavelets perform smoothing the texture is lost as the level of decomposition increases. If the medical image is degraded, then diagnosis becomes difficult. Loss of texture from the image makes it unfit for diagnosis. Image de-noising is done based on wavelet coefficient thresholding, also called wavelet shrinkage. The majority of wavelets filters have been used for de-noising in a variety of medical imaging applications. A basic procedure is to compute the discrete wavelet transform of the image followed by wavelet coefficients based noise suppression and finally performing the inverse wavelet transform DWT to reconstruct the de-noised image.

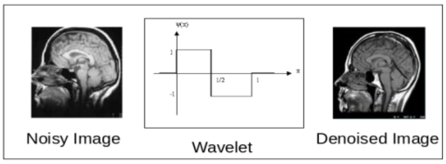

Figure 1 Wavelet medical image de-noising

The threshold has an important role in the de-noising of images. In image processing, thresholding is used to split an image into smaller segments or junks, using at least one color or grayscale value to define their boundary. It's often the initial step in a sequence of image-processing operations. Figure-1 shows the basic operation of de-noising process. Wavelet de-noising removes the noise present in the image while preserving the image characteristics regardless of its frequency content. Wavelets preserve visual quality and also maintain the diagnostically significant details of medical images. The purpose of de-noising is to remove the noise while retaining the edges and other detailed features as much as possible. The purpose of image de-noising is to estimate the original image from the noisy data. Noise in the image causes two negative effects, firstly it degrades the image quality and secondly, it conceals important information required for accurate diagnosis.

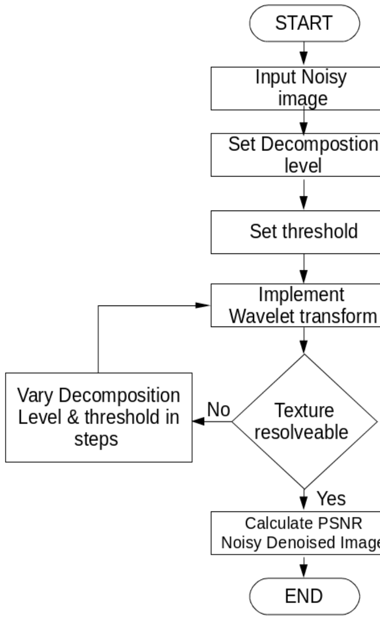

Figure 2 Flowchart for de-noising process

The complete de-noising operation is represented by the flowchart in figure: 2. the parameters decomposition level and threshold are adjusted to optimize the image restoration. Therefore we have to find out optimal values for reconstruction of degraded images so that images can be processed as per requirement. The de-noising technique should not cause loss of edge information and other important details which render it unfit for diagnosis. The wavelet approach is used for enhancement. Enhancement involves smoothing speckles at homogeneous areas and preserving thin details and edges. Applications of these methods on ultrasonic images provide a significant improvement of speckle reduction. Similarly if image is decomposed at large levels, details are lost. Hence image should be de-noised in such a manner that degradation does not occur and optimum de-noised image is obtained. The parameters have to be optimized in such a way that image can be used for processing.

3. Results

Wavelet transforms impact image de-noising depending on the noise levels. Noise added artificially is closely approximated to real life situation noise for implementing image processing. When applying *haar* wavelet at decomposition level of four an effect known as blocking is observed in the reconstructed image changing the threshold level improves the performance to some extent, which is further dependent on the level of noise. The level of thresholding is also important factor to reconstruct the image with more details present in it. With different data sets varying the noise level and other wavelet transform control parameters results were analyzed to find a better value of PSNR. The graphs represent PSNR of image obtained after De-noising. Processing a noisy image with wavelets at higher decomposition levels, changing the type of wavelet and again processing, the blocking effect is eliminated but another effect called ringing is introduced in the de-noised image. This ringing effect is observed clearly with *sym6* wavelet implementation. By adjusting the threshold levels in wavelet operation the output of the process provides acceptable results at particular values only. In course of de-noising when the threshold levels are adjusted this ringing effect also disappeared.

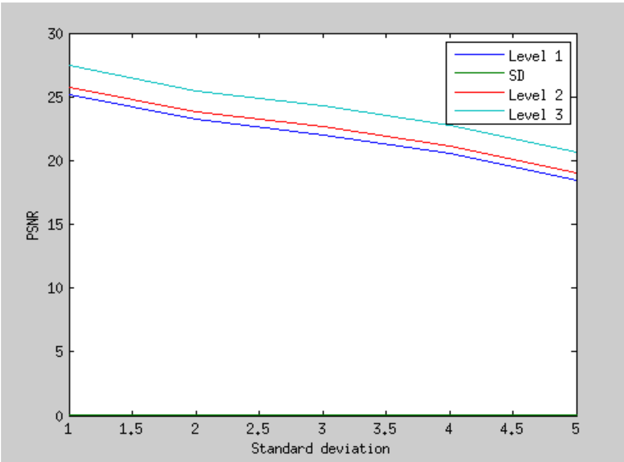

Figure 3 Graph of standard deviation and PSNR for different levels of decomposition

A graph in figure-3 shows the PSNR values for input (noisy) and resulting de-noised image when varying the standard deviation of noise in image for three different levels of decomposition. Another plot in figure-4 shows the MSE with different decomposition levels in image de-noising process.

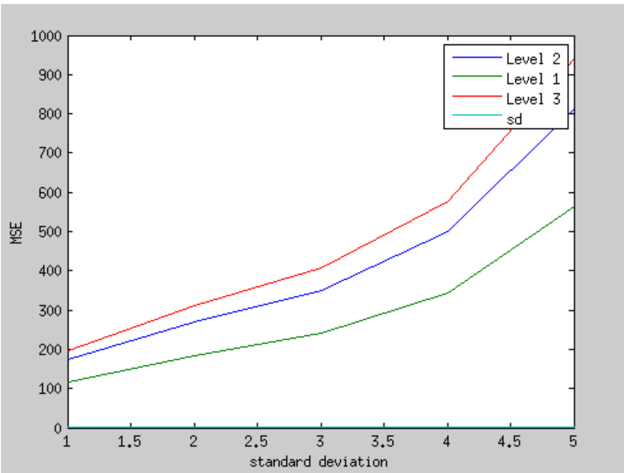

Figure 4 Graph of standard deviation and MSE

In this particular case comparison shows that the optimum value of PSNR over the minimum and maximum range of noise is for fixed value of threshold. Another observation is also made that present algorithm is not suitable to apply thresholding where the illumination is highly varying. Proposed method is implemented on medical images affected with noise. The noise level is varied and results are observed. The quality of restored image is not acceptable as level of threshold increases. The approach is tested on different medical images like x-ray images and ultrasound images obtain set of values for proper image denoising.

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