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Denoising of Gaussian and Speckle Noise from X-Ray Scans using Haar Wavelet Transform

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Abstract: ***This paper presents an algorithm for reducing speckle and Gaussian noise from medical X-Ray scans. Haar wavelet analysis has been applied to eliminate noise while preserving the sharpness of salient features. Both the noise forms are augmented in the input x-ray scans. The level of 30% noise is added into the input X-ray image. The image is decomposed upto level 2 using soft thresholding technique. The approach for speckle noise reduction is shown to be more effective than that affected by Gaussian noise. A study using a clinical X-Ray image suggests that such denoising and enhancement may improve the overall consistency of expert observers to manually defined borders.***

Keywords: Image denoising, X-rays, discrete wavelet transform, gaussian noise, speckle noise.

1. Introduction

The degraded qualities of medical images have been reported by several researchers due to interference of some kind of noise. The domination of a kind of noise depends on the type of a medical image [1]. For example; ultrasounds are often suffer from the speckle noise while low contrast parameter are frequently exhibit in radiographs [2]. For the purpose of improvement in image quality, interpretation and analysis with the help of computer-assisted methods is necessary. Image enhancement helps in extraction of image parameters from the medical images for proper diagnoses [3-8]. Computer based detection of anomalous growth of tissues in a human body are preferred than manual processing methods in the medical investigations because of accuracy and satisfactory results. In this regard, various techniques have been proposed by different researchers, specifically, spatial and frequency-based techniques [9] [10]. The spatial and filtering-based methods for image de-noising often reduce noise by altering some parameters related to blurred features while predictable methods for contrast enhancement may also amplify the noise content in an image. The work in the area of image processing have been developed from the past several years but the specific image enhancement schemes especially for medical imaging have been studied during the last two decades. Initially, the de-noising and feature enhancement techniques were supposed to be two different topics of argument [11]. Later on, they are found to be the two sides of the same coin. The de-noising is used to eliminate noise, especially in high-frequency bands while as image enhancement improves some specific signal details. The main difference between the two is that characteristics in the image often occupy a wider frequency band than noise [2] [12]. It is even more difficult to achieve both objectives when signal details are corrupted by noise. The realization of image de-noising and image enhancement techniques is possible simultaneously by lowering the noise energy and raising feature energy through nonlinear processing of wavelet coefficients in the transform domain [2].

This paper is organized as follows. The methodology for image enhancement using wavelet analysis is described in Section 2. Section 3 includes the experimental results and discussions. Finally, Section 4 concludes the paper.

2. Page Size and Layout

In this experiment, an input X-ray image is de-noised using two popular wavelet techniques and the single decomposition level has been taken into account using a discrete wavelet packet. The wavelet transformations used in this experiment is Haar wavelet transform. The noises added in the synthesized image are Gaussian and speckle noise. The input image is decomposed at depth 2 and the steps taken into consideration are shown in fig. 1 in the form of the flow chart.

The method is clearly explained from the flow chart. After pre-processing the input medical X-ray image, the noise is augmented into with variance value 0.4 and zero mean. This synthesized image is decomposed upto 2nd level using Haar wavelet transform. The decomposed image after denoising is calculated for peak signal to noise ratio (PSNR) and mean square error (MSE). The noise content in an output image may be present but is less noisy as compared to noisy image.

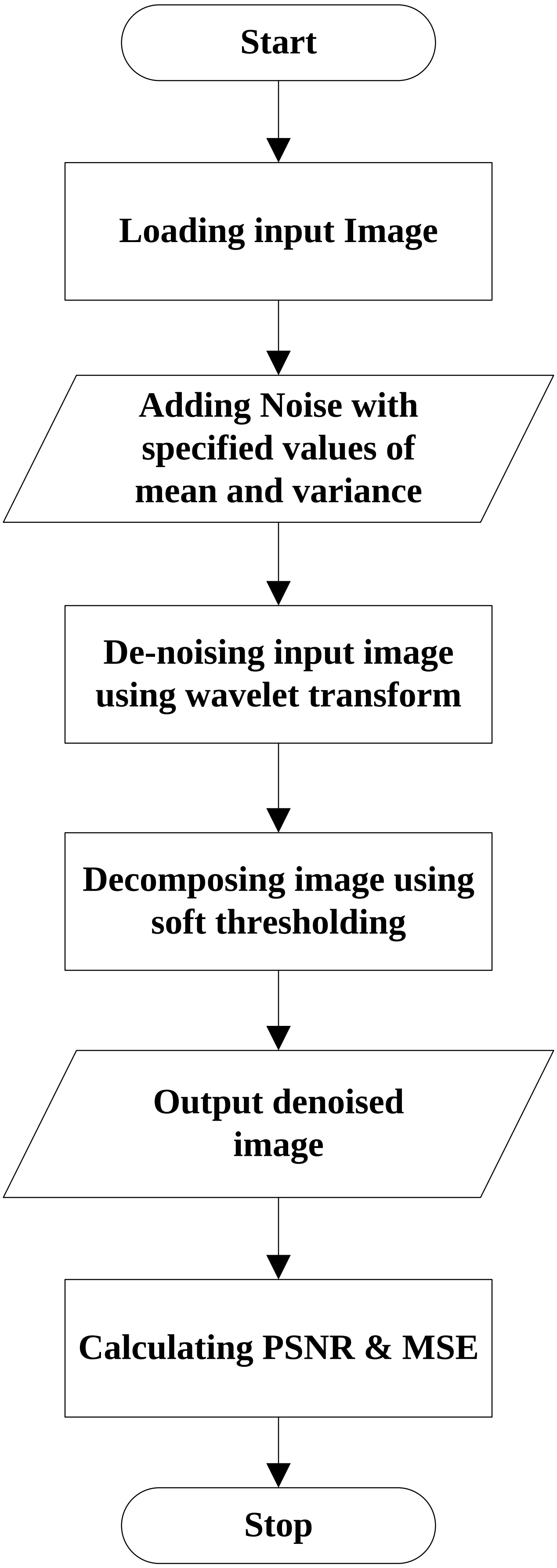

Figure 1: Steps taken for X-ray image denoising

The threshold value is selected for different sub-band to determine the scale parameter. Soft thresholding is applied to sub-bands to reconstruct the de-noised image. The PSNR is calculated in decibel units (dB), which measure the ratio of the peak signal and the difference between two images.

3. Results and discussions

Fig. 2 shows the input image of X-ray scan taken from the internet source. The noise content in an input image is added. Two different kinds of noise are added, i.e., Gaussian noise and the speckle noise.

Figure 2: Input X-Ray Image

The noised images are shown in fig. 3 and fig. 4. Fig. 3 shows the original xray image added with Gaussian noise while in fig. 4, speckle noise is added.

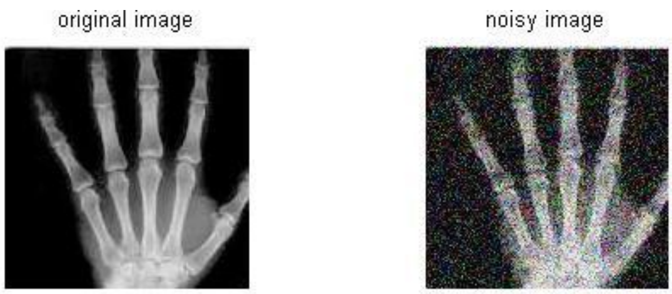

Figure 3: Original Image vs Gaussian Noised Image

Figure 4: Original Image vs Speckle Noised Image

The de-noised image is then decomposed using soft thresholding. In the orthogonal wavelet decomposition procedure, the generic step splits the approximation coefficients into two parts. After splitting we obtain a vector of approximation coefficients and a vector of detail coefficients, both at a coarser scale. The information lost between two successive approximations is captured in the detail coefficients. Then the next step consists of splitting the new approximation coefficient vector, successive details are never reanalyzed. Figure 5 shows the decomposed image at level 2 with Haar wavelet for Gaussian noised image while fig. 6 shows the decomposed image for speckle noised image.

Figure 5: Decompoed image after Gaussian noised image

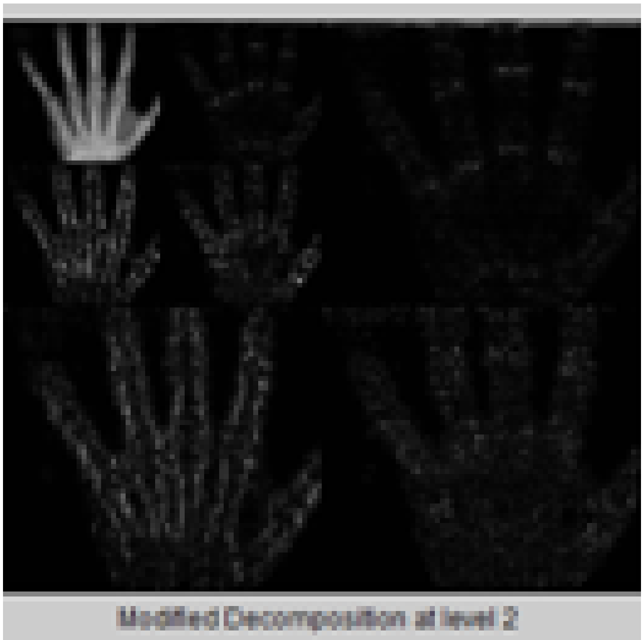

Figure 6: Decompoed image after speckle noised image

Wavelet thresholding is a signal estimation technique that exploits the capabilities of wavelet transform for signal denoising. It removes noise by killing coefficients that are insignificant relative to some threshold. Soft thresholding shrinks coefficients above the threshold in absolute value. Figure 7 shows the reconstructed image after denoising using Haar WT while fig. 8 shows the reconstructed image after Symlet transform.

Figure 7: Denoised Image after Gaussian noise reduction

Figure 8: Denoised Image after speckle noise reduction

Finally, the PSNR and MSE are calculated and the results showed that the value of MSE is 0.0919 and the value of PSNR is 31.1587 while considering Gaussian noise. For considering, speckle noise, the results showed the value of MSE as 0.0592 and PSNR is 36.0737. The MSE and PSNR were calculated in-between the original input image and that of the output reconstructed image.

4. Conclusion

This can be concluded that the de-noising of X-ray input image using Haar wavelet is effective for image reconstruction. The importance of enhancing the medical scans is very important to expose the hidden information into it. The input X-ray image is processed using Haar WT at level 2. Results shows that the de-noising the speckle noise from the X-ray images is more effective than de-noising the Gaussian noise. During compilation, the decomposed image has been de-noised to generate a super resolved imaged. The proposed experiment shows good and economical de-noising method while calculating PSNR and MSE. A visual result confirms that the proposed technique is better for de-noising speckle noise than de-noising the Gaussian noise. However both results show better results than the conventional image enhancement technique.

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