Denoising of Coronary artery X-ray angiography image using UDWT

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Abstract: The accurate assessment of coronary stenosis is essential for the diagnosis of cardiovascular disease and is an important predictor of major adverse cardiac events. Image noise originates from noise projection measurement, having quantum noise and electronic noise. Most of the noises of X ray Angiography images are found to have approximately Additive white Gaussian noise. This confines the accuracy of diagnosis of stenosis in coronary Angiography images. Therefore a more honest understanding of the noise properties in medical imaging is required for the accurate diagnosing in medical imagery. The suggested method requires a novel image denoising algorithm using a 2D undecimated discrete wavelet Transform (UDWT) which has turned out to be superior to previous image denoising algorithms. The proposed method is validated by determining Peak signal noise ratio (PSNR).

Key words: Denoising, Gaussian noise, undecimated discrete wavelet transform, coronary artery angiogram, X- ray Angiography.

1. INTRODUCTION

X-ray Angiography is a widely used imaging modality for the diagnosis of the coronary artery diseases. A major disadvantage of CT is the use of ionizing radiation, which may induce cancer in the exposed individual. Diminution of radiation dose used in CT will therefore lead to a decrease in the number of induced cancers. Reduction of the radiation dose, however, will increase the amount of photon noise in CT images, which will degrade the image quality. Even though there are several other effects such as artefacts and subject movement that influence CT image quality, photon noise contributes the most to CT image quality degradation .The accurate assessment of coronary stenosis is essential for the diagnosis of cardiovascular disease and is an important predictor of major adverse cardiac consequences. CT image noise originates from noise projection measurement, having quantum noise and electronic noise. Mostly the noises of CT images are found to have approximately Additive white Gaussian noise. This limits the accuracy of diagnosis of stenosis in coronary Angiography images. Thus a more honest apprehension of the noise properties in medical imaging is required for the accurate denoising in medical imaging. Several image denoising algorithms were applied to CT image noise reduction such as anisotropic diffusion filter, wavelet based structure-preserving filter, DWT and nonlocal means (NLM). The suggested method requires a novel image denoising algorithm using a 2D undecimated discrete wavelet Transform (UDWT) which has turned out to be superior to previous image denoising algorithms. The denoising result of the UDWT has a better balance between smoothness and accuracy than the DWT. In this paper, the image denoising problem will be formulated and some of the preliminary issues such as the assumptions about the noise, estimation of the noise variance and quality assessment criteria of the denoised image will be discussed. The results shows a comparison of Haar, Daubecheis wavelet transform Wavelets for Image denoising for coronary angiography images.

2. PROPOSED FLOW PROCESS OF IMAGE DENOISING

The proposed flow process of the proposed method is shown in Figure 1. For the analysis the coronary angiogram was considered as the input image. The noise can be estimated in terms of standard deviation. If the standard deviation is increased means the noise level is also increased. Then the image is subjected to denoising using undecimated discrete wavelet transform. The denoising procedure using wavelet analysis involves the following steps:

- Applies the UWT to noise-contaminated images to obtain the UWT coefficients. The noise usually corresponds to the coefficients with small values.
- Selects an appropriate threshold for the UWT coefficients to set the coefficients with small values to zero. The bound of noise reduction with these methods is 3 dB. To achieve better denoising performance an appropriate threshold can be manually selected by specifying the user defined thresholds parameter of the WA Denoise.
- Reconstructs the signal with the inverse UWT.

The output image after reconstruction is a denoised image. The above said procedure is repeated for various noise levels and the performance and the quality of the image is estimated in terms of peak signal to noise ratio (PSNR). A comparison of PSNR for different noise level is estimated to take the optimal value.

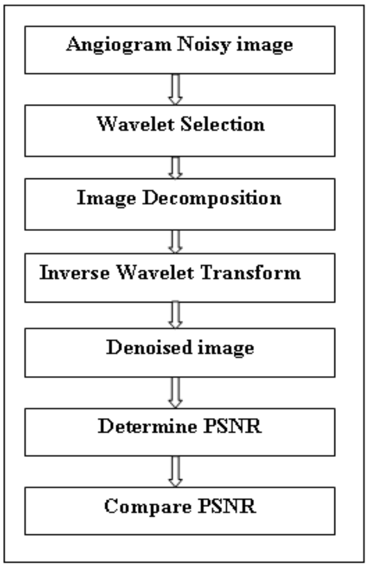
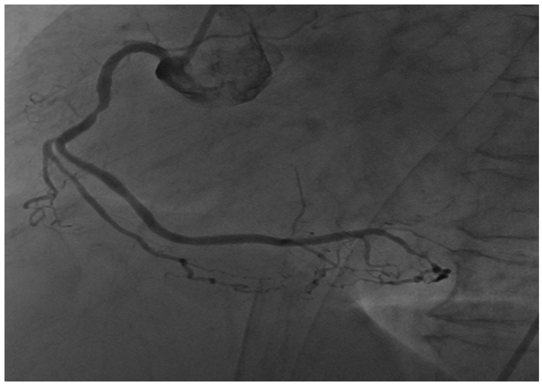


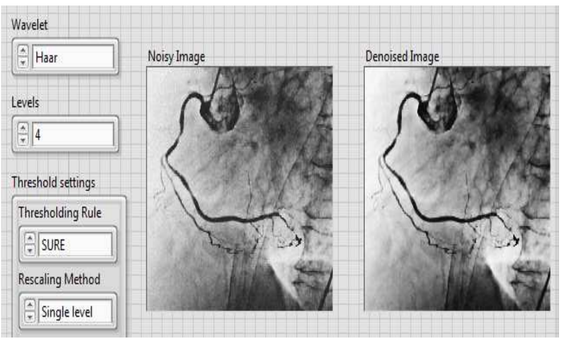
Figure 1. Flow process of the proposed method of image denoising

3. RESULTS AND DISCUSSION

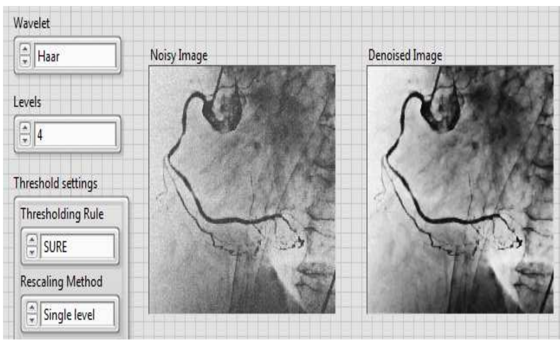
The performance of the proposed method was tested on a real dataset collected from Government Rajaji Hospital, cardiology section, Madurai, India. A noise model is developed assuming the noise as Gaussian noise for various levels of standard deviation sigma (σ) of 10, 20, 30 and 40. In order to have a comparative analysis the noisy image is filtered using linear low pass smoothing filter and Gaussian filter. And so the proposed denoising method is subjected to Haar and Daubecheis (db2) wavelet transforms for denoising respectively. The Peak Signal to Noise Ratio (PSNR) is the quality criteria applied to assess the response of denoising. It is assumed that high values of PSNR is a mark of the effective restoration. PSNR was calculated at different level of Gaussian noise on each coronary angiography image at soft and hard thresholding levels by applying these Haar,bior and db2 wavelets one after another and then the comparison is made. The qualitative and quantitative analysis is carried out using Ni Lab VIEW, version 13.0.To implement the proposed method studies was made on coronary angiogram contaminated at a desired level by white Gaussian noise. Measuring the performance of the proposed denoising method is done by calculating the PSNR value. The assessments were made about the behaviour of different wavelets types. Wavelet specifies the wavelet type to utilize for the discrete wavelet analysis. The types of wavelet include orthogonal (Haar, Daubechies (db*xx*), Coiflets (coif*x*), Symmlets (sym*x*)) and biorthogonal (Biorthogonal (bior*x_x*),) where *x* indicates the order of the wavelet.



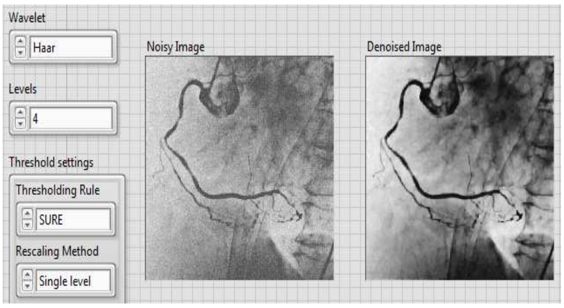
(a)



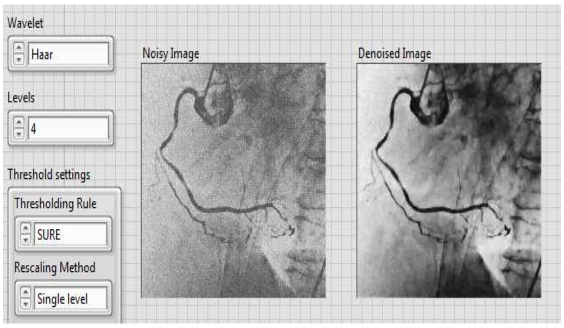
(b) **σ** =10



(c) **σ** =20

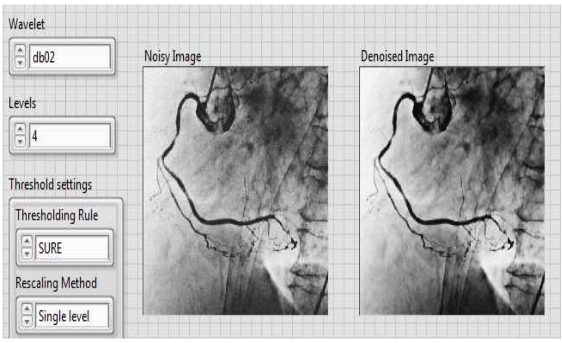


(d) **σ** =30

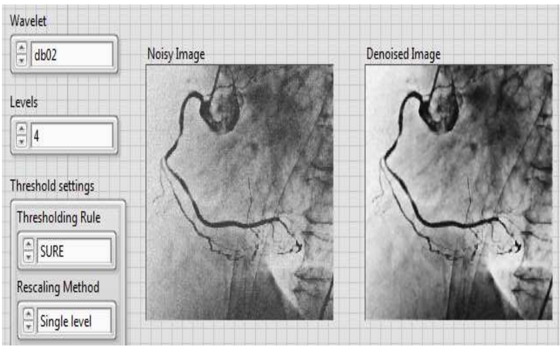


(e) **σ** =40

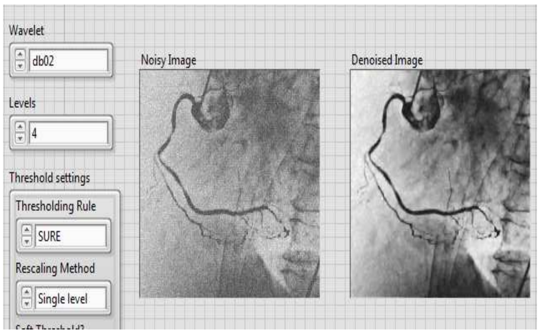
Figure 2. Noisy image and denoised image subjected to Haar wavelet for various sigma value of (a) Original image, (b) Noisy image and denoised image for Haar wavelet for **σ**=10 (c) Noisy image and denoised image for Haar wavelet for **σ**=20 (d) Noisy image and denoised image for Haar wavelet for **σ**=30 (e) Noisy image and denoised image for Haar wavelet for **σ**=40



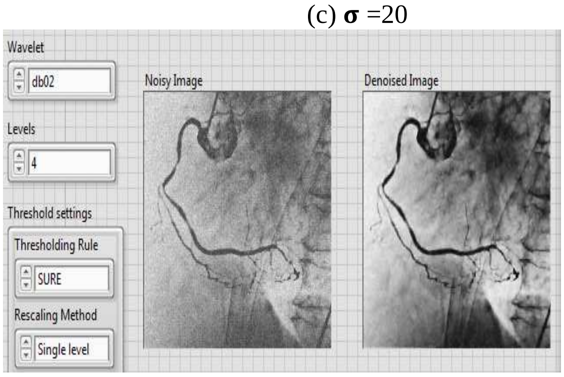
(b) **σ** =10



(c) **σ** =20

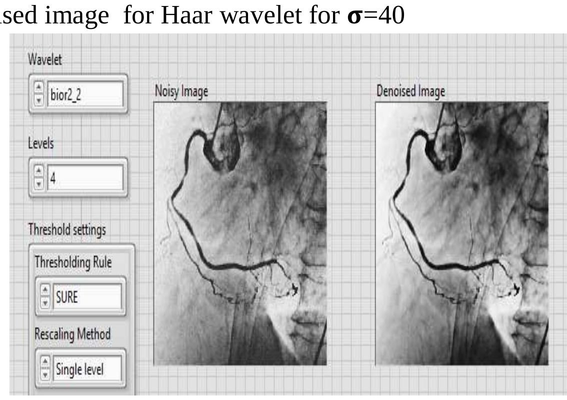


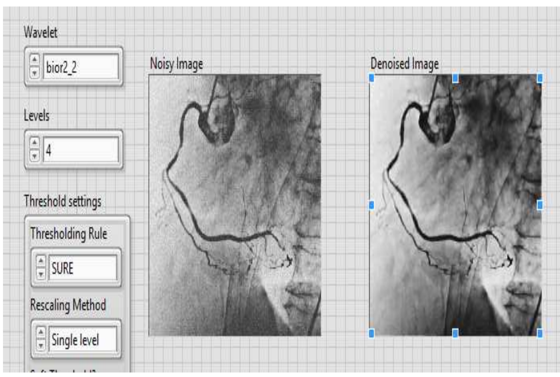
(d) **σ** =30



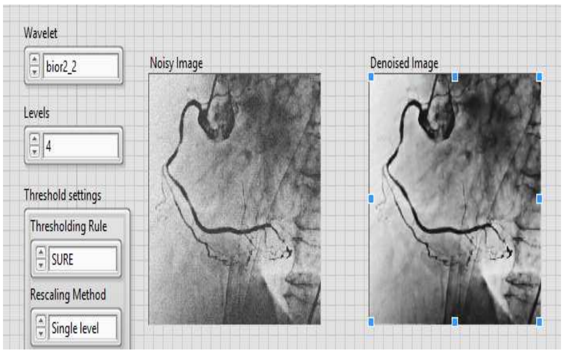
(e) **σ** =40

Figure 3. Noisy image and denoised image subjected to db02 wavelet for various values of sigma (a) Original image, (b) Noisy image and denoised image for db02wavelet for **σ**=10 (c) Noisy image and denoised image for db02 wavelet for **σ**=20 (d) Noisy image and denoised image for db02wavelet for **σ**=30 (e) Noisy image and denoised image for Haar wavelet for **σ**=40

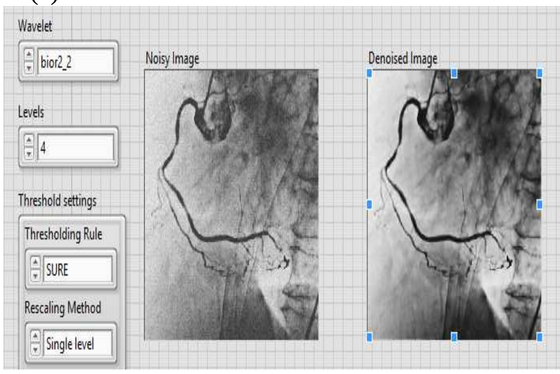




(b) **σ** =10



(c) **σ** =20



(d) **σ** =30 (e) **σ** =40

Figure 4. Noisy image and denoised image subjected to bior wavelet for various values of sigma (a) Original image, (b) Noisy image and denoised image for bior wavelet for **σ**=10 (c) Noisy image and denoised image for bior wavelet for **σ**=20 (d) Noisy image and denoised image for bior wavelet for **σ**=30 (e) Noisy image and denoised image for bior wavelet for **σ**=40

Table 1 Comparative PSNR for different types of wavelet

Wavelet Type	Noise Level: Standard Deviation **σ** (db)	Minimum Value		Maximum Value		PSNR for noised image(db)	PSNR for denoised Image(db)
		Noisy image	Denoised image	Noisy image	Denoised image		
Bior2_2	10	421	492	17364	1709	2.496	**24.56**
	20	361	473	17293	1810	2.408	**19.32**
	30	395	490	17232	1607	2.505	**24.50**
	40	516	411	17182	1373	2.60	**33.86**
Haar	10	488	279	17405	1311	2.470	**20.78**
	20	486	240	17260	1480	2.480	**15.36**
	30	479	276	17390	1197	2.426	**22.76**
	40	497	290	17468	1476	2.50	**19.06**
db_02	10	476	392	17394	1311	2.410	**20.49**
	20	454	362	17342	1480	2.30	**17.61**
	30	489	386	17275	1197	2.49	**23.60**
	40	476	359	17261	1476	2.42	**19.16**

Figure 2 illustrates the UDWT denoising with haar wavelet for **σ** of 10,20,30 and 40db. Figure 2 (a) comprises the original coronary artery image. Figure 2 (b),(c),(d),(e) shows the noisy image and denoised image for haar wavelet. Figure 3(b),(c),(d),(e) shows the noisy image and denoised image for db02 wavelet. Figure 4(b),(c),(d),(e) shows the noisy image and denoised image for bior wavelet. Table 1 shows the comparative quantitative analysis of estimation of PSNR for various noise level **σ** of 10,20,30 and 40db. A comparison is made for different wavelet and it was found that the highest PSNR value is obtained for bior wavelet which depicts the highest quality of the image.

4. CONCLUSIONS

In this paper the potential and the effectiveness of the proposed approach for diagnosing the coronary angiogram is demonstrated and tested through a serial publication of experimental simulations. Here it is focused mainly to denoise the Angiogram images through the proposed method. From the simulations, it has been observed that the proposed system is capable of removing the noise well on the images. Undecimated discrete wavelet analysis plays a really important part in getting rid of the noise and it delivers a really good noise removing capability. The analysis of pixels at various scales extremely reduces the noise and avoids introducing visual artifacts. The results in terms of PSNR are found to be comparable and superior to other approaches and deserve to be a reliable system for preprocessing the coronary Angiograms.

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