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Noise removal from medical image using fusion technique based on DWT coefficient

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Noise removal from medical image using fusion technique based on DWT coefficient

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Abstract . This paper introduces new manner for removing noise from medical images using wavelet transform based on fusion technique. The main goal of this research is restaurant the medical image based on peak signal to noise ratio value. This paper contains of three key stages are discrete wavelet transform, denoising wavelet and fusion technique. The new idea is compared each sub band of wavelet with other sub band depend on PSNR value and is selected the higher value of measure. First, perform 2level of discreet wavelet transform on the noisy medical images .Then, perform denoising wavelet techniques (soft and hard thresholding) that achieved by threshold value for detail coefficient and compared it with wavelet coefficients for detail sub band. Second , select sub band that contains the higher peak signal to noise ratio value that has less amount of noise from each image and it is merged to form the fused image. Finally, perform inverse discrete wavelet transform to convert the output image (fused image) from frequency domain to spatial domain. The outcomes of the work showed that soft thresholding is better than hard thresholding based on higher PSNR value. The fusion process gives better results than wavelet denoising technique.

Keywords: Denoising Wavelet , Discrete Wavelet Transform, Image Fusion , Medical Image, Noisy Image, PSNR.

1. Introduction

Image enhancement is an important part of image processing and computer vision. Image enhancement is the process of improving the quality of image and content of information before processing. In general , images are degraded from through noise , contrast and blur. Noise is removed by using filters in spatial domain and wavelet denoising in frequency domain. Contrast is enhanced by using histogram equalization. Blur can be removed by using blind Deconvolution , wiener filter and inverse filtering. In this work will explain about noise removal in frequency domain based on denoising wavelet.

2. Discrete wavelet transform

Discrete wavelet transform is one of the image fusion techniques. DWT is used in many applications like image denoising, image compression, speech recognition and fractal recognition [1] .

The input image is applied by dwt to produce approximation coefficients and detail coefficients. The approximation coefficients of each level are the input of the next level. The LL1 sub band is decomposed find out the next approximation level [2].

DWT of image is found by passing it on low pass and high pass filters. Low pass filter creates approximation coefficients while high pass filter creates the detail coefficients. The approximation coefficient and detail coefficient can be computed according to the equations (1 , 2):

$$a(r,c)=\sum_{k} x(r,k)l(c-k) \quad (1)$$

$$d(r,c)=\sum_{k} x(r,k)h(c-k) \quad (2)$$

Where x represent the original image , l and h represent the low pass and high pass filters respectively. Figure 1 represents the structure of 2D discrete wavelet transform [3].

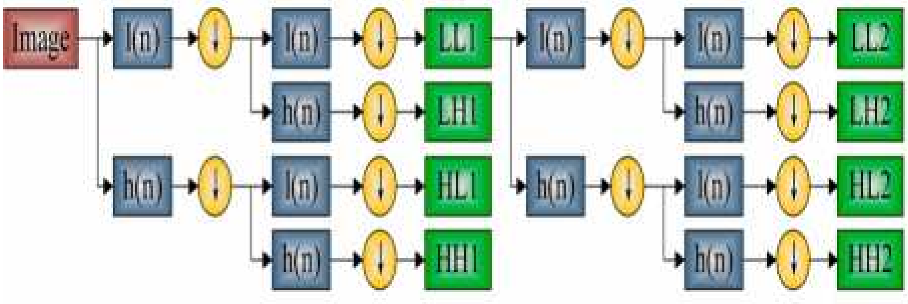

Figure 1. Discrete wavelet transform of two- level decomposition [3].

3. Denoising wavelet

An image is degraded by noise from through transmission or acquisition. Image denoising is the process of eliminating noise from images and preserving useful information. Wavelet denoising is noise removal process by using wavelet method.

There are two types of thresholding methods in wavelet denoising are soft and hard thresholding. Wavelet denoising is performed via comparing coefficient with threshold [4].
If its wavelet coefficient is smaller than threshold, it will represent to zero (in the hard thresholding) , while it will retain unchanged (in the soft thresholding). Threshold value is calculated according to the equation (3):

$$T = \sigma\sqrt{2\log(n * m)} \quad (3)$$

Where T is universal threshold, σ is the noise standard deviation, n and m are the dimensions of image [5].
There are various kinds of noise in image processing are Gaussian, Poisson , salt & pepper and speckle noise. Gaussian noise follows additive noise. In color cameras blue color is more amplifier from red and green colors, for this reason blue channel is more noise from red and green channels. Poisson noise is one of kinds electronic noise that happens once the limited number of electrons in an electronic circuits. Salt and pepper noise is more popularly found in the images.

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Speckle noise is multiplicative noise that found in laser , radar and SAR images (see Figure 2) [6].

4. Image Fusion

Image fusion is the process of combination the information from set of images to form one image that is more informative than of the original images. The main objective of fusion process is enhancement images and giving output image that more clarify than original images .

The fusion method should attain the following situations:

- It retains all information in the fused images.
- It prevents dissimilar parts of the image as noise.
- It decreases any ambiguity in the fused image [3].

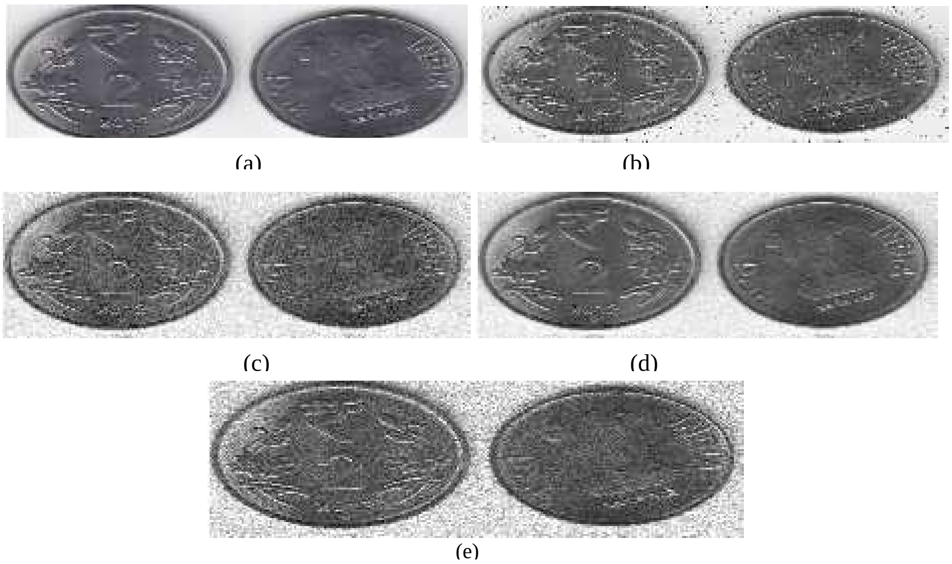

Figure 2. original image and noisy images (a) Original image without noise (b) Image with salt & pepper noise (c) Image with Gaussian noise (d) Image with Poisson noise (e) Image with speckle noise [7].

5. Related Work

This section introduces some of previous works that their closeness to the paper as table 1.

Ram Nivas and Himanshu Agarwa [8] presented fusion of medical image using wavelet. They used the wavelet transform, PCA for fusing and bicubic interpolation while in this paper is used discrete wavelet transform to remove the noise and improved the edge between sub bands by using fusion method depends on higher PSNR value for each sub band.

Arin H. Hamad et.al. [9] presented noise removal from medical images in spatial domain. They used various kinds of filters are Average filter , Log filter, Gaussian filter, Wiener filter and Median filter. In this paper is used wavelet denoising using threshold to remove the noise from the medical images in the frequency domain in addition to fusion process for producing the optimal image.

Prerana and Deepali [10] presented efficiency MRI and CT images fusion methods. They extended this method by using curvelet transform with wavelet transform methods to achieve the objective of improving the performance while in this work is used wavelet transform with fusion method based on higher PSNR value of each sub band.

Hari and Smriti [11] discussed MRI and CT image fusion by using wavelet transform. They implemented the wavelet transform by using fusion rules like maximum, minimum and average methods on the images. They decided that maximum method provides result better higher PSNR values. In this paper is computed wavelet coefficient for each sub band based on higher PSNR value. PSNR value of sub band is compared with value of other sub band and is selected higher value to form the fused image.

Nayera Nahvi and Deep Mittal [12] proposed medical image fusion using DWT. They used different fusion methods of dwt including pixel average, max min and min max for medical image fusion while in this paper is used wavelet coefficient with fusion based on the higher PSNR measure of each sub band and comparing with other sub band to select the optimal sub band to produce the fused image and not based on maximum or minimum or average of wavelet coefficient.

Table 1. Comparative study of related work with this work.

No. of Reference	The algorithm	Denoising Domain	Types of The used Thresholds	Fusion method
8	Discrete wavelet transform	——	——	PCA
9	Filters	Spatial domain	Average filter , Gaussian filter, Wiener filter and Median filter.	——
10	curvelet transform with wavelet transform	——	——	curvelet transform with wavelet transform
11	Discrete wavelet transform	——	——	maximum, minimum and average
12	Discrete wavelet transform	——	——	pixel average, max min and min max
This work	Discrete wavelet transform	Frequency	Wavelet denoising (Universal and soft threshold)	Different sub band of wavelet based on PSNR value

6. Materials and Methods

The proposed work is illustrated in Figure 3 that includes many of steps:

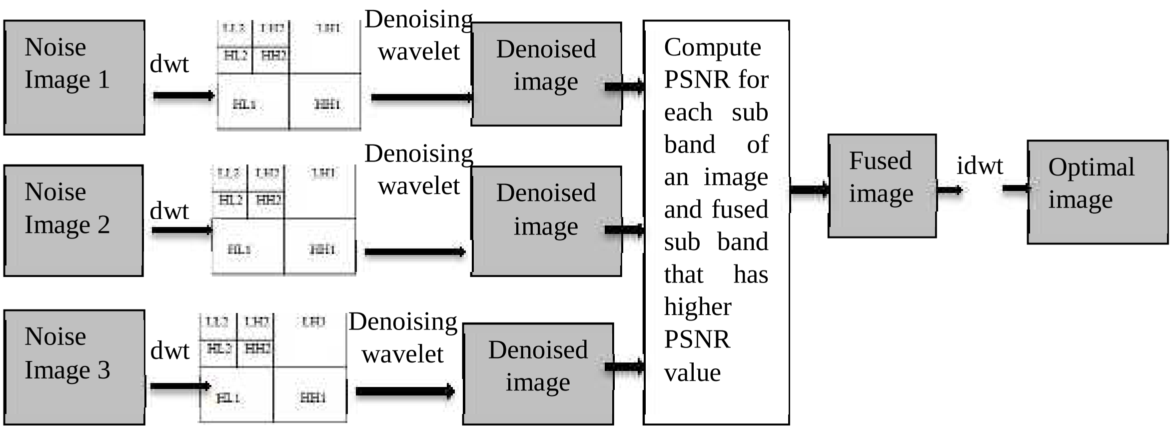

Figure 3. Block diagram of the proposed work.

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The block diagram in above contains of many stages are:

6.1.Input set of images

the images used in this paper are noise medical images. These images will be converted to two dimensions array with size M*N. These images were of same size and same scene but capturing under different conditions.

6.2. Apply wavelet transform for each image

perform wavelet transform on each image with two level will consists seven sub bands as clarified in Fig. 3 are the vertical, horizontal , diagonal and detail coefficients for each level. DWT coefficient are calculated by using low pass filter and high pass filters on the images and then down sampling process on both rows and columns of images according to equations (1) and (2).

6.3. *Apply wavelet denoising for each image*

in this step is applied hard and soft thresholding to calculate threshold value for detail sub band and compared with wavelet coefficient according to the equation (3) . The soft and hard thresholding computed according to the equations (4) and (5) respectively.

$$\tilde{X}[n] = \begin{cases} Y[n] - T & Y[n] \geq T \\ Y[n] + T & Y[n] \leq -T \\ 0 & |Y[n]| < T \end{cases} \quad (4)$$

$$\tilde{X}[n] = \begin{cases} Y[n] & \text{if } |Y[n]| \geq T \\ 0 & \text{otherwise} \end{cases} \quad (5)$$

6.4. *Calculate PSNR for each sub band*

in this step is computed PSNR value for each sub band of images and for each level of discrete wavelet transform. The optimal sub band is the better for selecting it to form fused image that has the highest PSNR value.

For example they have three images and they compute PSNR for sub band LH1:

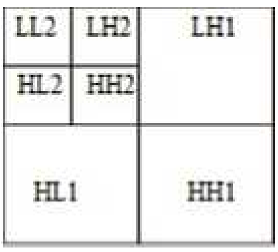


Image (1)

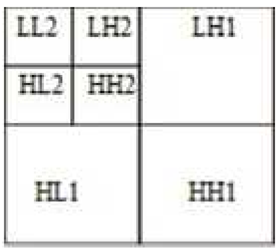
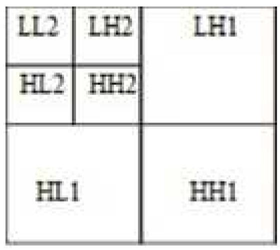


image (2)



image(3)

Now calculate sum PSNR for three image for LH1 sub band as follow:

Image 1 = 10+20 = 30 ,
Image 2 = 10+40 = 50
Image 3 = 20+40 = 60
PSNR_LH1 between (image 1 and image 2) = 10
PSNR_LH1 between (image 1 and image 3) = 20
PSNR_LH1 between (image 2 and image 3) = 40

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The higher PSNR is 60. The image 3 is better for selecting sub band LH1 to form fused image. The same method is repeated on the rest of other sub bands to select the optimal sub band. The fused image is the combining optimal sub bands that has higher PSNR for each image (in frequency domain).

6.5. Apply inverse discrete wavelet transform (IDWT)

This step implements on the resulted image (fused image) to transform the image from frequency domain to the spatial domain. IDWT is computed by finding low and high pass filter in reverse manner compared with DWT process to get on the output image (optimal image) that it resulted from merging optimal sub bands form each image.

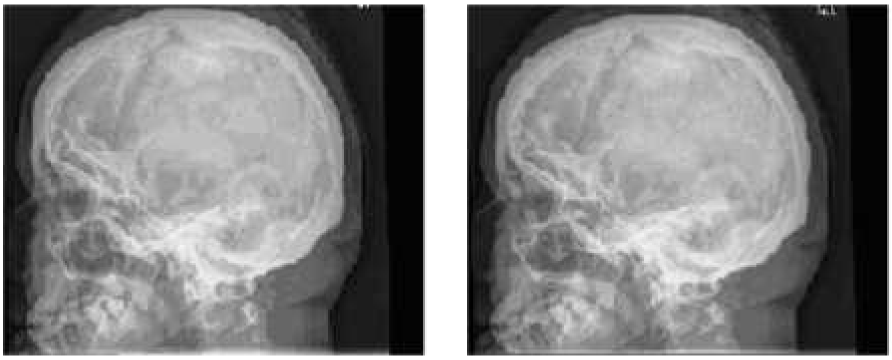
7. Results and Discussion

The results are implemented on 3 original medical noisy images (see Figure 4).

(a) Gaussian noise (b) poisson noise (c) salt&pepper noise

Figure 4. The noisy medical images.

Figure 5 clarified applying fusion process on medical noisy image to produce the optimal image (fused image). Fusion process is used based on PSNR metric to determine the optimal sub bands that has less noise of image. Inverse discrete wavelet transform is applied on the fused image to convert from the frequency domain to the spatial domain.



(a) fused by Soft thresholding (b) fused by hard thresholding

Figure 5. The fused medical images.

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Table 2. Results PSNR of sub band for universal thresholding of noisy images (200*200).

Sub bands of images	Peak Signal to Noise Ratio Soft Universal thresholding	Hard Universal thresholding
LH2 of image 1 and 2	50.994	25.791
LH2 of image 1 and 3	33.546	22.278
LH2 of image 2 and 3	51.736	26.173
HL2 of image 1 and 2	28.803	24.659
HL2 of image 1 and 3	31.312	25.625
HL2 of image 2 and 3	27.298	22.695
HH2 of image 1 and 2	48.130	40.440
HH2 of image 1 and 3	53.884	38.210
HH2 of image 2 and 3	53.884	37.959
LH1 of image 1 and 2	48.130	48.130
LH1 of image 1 and 3	47.132	43.063
LH1 of image 2 and 3	47.132	43.063
HL1 of image 1 and 2	37.632	26.973
HL1 of image 1 and 3	30.674	25.557
HL1 of image 2 and 3	34.887	37.856
HH1 of image 1 and 2	79.831	37.339
HH1 of image 1 and 3	55.367	36.766
HH1 of image 2 and 3	55.383	45.848

Table 2 shows PSNR values for universal threshold with soft and hard thresholding of between sub bands while Table 3 shows the sum of PSNR values of each sub band. The image that has value higher of PSNR is the better for selecting it**.**

Table 3. Sum PSNR of sub band for universal thresholding of noisy images (200*200).

No. of Levels	No. of Images.	sub band	Soft Universal thresholding	Hard Universal thresholding
1	Image 1	LH	143.394	139.324
		HL	103.821	74.864
		HH	214.589	110.579
	Image 2	LH	143.394	139.324
		HL	109.367	89.659
		HH	224.765	127.087
	Image 3	LH	141.398	129.189
		HL	97.504	88.201
		HH	166.132	124.370
2	Image 1	LH	136.276	74.243
		HL	87.414	72.980
		HH	150.146	118.735
	Image 2	LH	139.713	79.585
		HL	101.997	84.619
		HH	150.146	117.366
	Image 3	LH	100.725	69.785
		HL	93.107	85.685
		HH	161.653	113.440

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8. Conclusions

This paper presents removing noise from medical images using wavelet fusion method. The outcomes of this work is signed that PSNR value soft thresholding is given higher than PSNR value of hard thresholding that means soft thresholding makes the image more clarifier than hard thresholding. Also , PSNR value for level 1 is higher than level 2 that means the image in level 1 is clearer than level 2. This paper is not work for merging two images because PSNR value for one image is equal to value of other image.

9. References

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