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Denoising of Images Using a Hybrid Image Fusion Algorithm

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ABSTRACT: The search for an efficient image denoising method is a challenging issue in the field of image processing. The main focus of this paper is to define an experimental methodology to reduce the noise in homogeneous area of the image and preserve the edges in the image. In the present work, a denoising method based on a hybrid image fusion using DDCT and PCA is proposed. Results are evaluated and compared by visual means, MSE, SNR, PSNR, RMSE and SF. Also, the numerical results show that the algorithm proposed is superior to traditional denoising filters used.

KEYWORDS: Image fusion, Directional transform, Discrete cosine transform (DCT), Principal component analysis (PCA) , Discrete wavelet transform (DWT), Spatial frequency.

I.INTRODUCTION

An image is basically encoded as an matrix of either grey values or colour values. Each pair *(i,u(i))* represents a picture element at point *i* [1]. In the case of an grey level image *u(i)* denotes a grey value whose intensity values ranges from 0 to 255 . 0 indicates minimum intensity value (black colour) and 255 indicates maximum intensity value (white), giving a total of 256 different levels of grey. On the otherhand in the case of classical colour image *u(i)* denotes tripplet of values including red, green and blue components. For simplicity, this paper includes the processing of grey level images. The limitations faced in image processing are usually categorized as Noise and Blur. Blurring of an image mainly happens due to incorrrect focus. Again the quality of an image is often affected by the presence of noise. Therefore denoising in these images must be carried out carefully such that the edges are preserved and noise from the homogeneous area are removed.

Noise can be mathematically expressed as an perturbation that affects the actual image(g) to produce a noisy image(f) during image acquisition.

$$f(i,j)= g(i,j) \,.\, n(i,j) + m(i,j)$$

where $f(i,j)$ is the noisy image, $g(i,j)$ is the noise free image , $n(i,j)$ and $m(i,j)$ are the additive and multiplicative noise[2].

The organization of the paper is as follows: Section 2 presents a brief summary of the literature survey, then Section 3 presents an overview of the proposed approach. In section 4, experimental results on denoising of images using a hybrid image fusion algorithm and quantitative results are presented. Lastly, Section 6 summarizes our conclusions and discusses the possibilities of further research in this area.

II.LITERATURE REVIEW

In the past few years, considerable amount of research attempts to reduce the noise affected by an image. Both pre-processing as well as post-processing techniques are developed including different types of filters like Lee filter [3], Median filter, Butterworth filter etc.

The study in [4] presents a simple filtering technique, in which the central pixel of a moving window is replaced by the window's median value. Again based on the type of noise model and presuming a model of speckle noise, more complicated statistical filters are developed such as lee , kaun filters etc. Basically, the lee filter is a moving-window based filter that involves a linear approximation approach [5]. The study in [6] presents the analysis of different kinds of wavelet based de-noising methods according to various threshold values applied to input images. Another popular

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linear filtering method among the spatial filters include Gaussian low pass filter, which successfully removes noise from a distorted image[7].

Noise degrades the quality of images i.e; the edge details fine details get suppresed and it may also potentially blur the image. Therefore, it becomes difficult to analyse an image and extract its important information. However, developing a denoising algorithm such that its edge and feature preservation is a challenging issue. As a result, such an attempt has been proposed based on some denoising filters accompanied by an hybrid image fusion method. Basically, fusion techniques includes the combination of similar type of images to produce a resultant image. Most commonly used fusion methods are principal component analysis (PCA) based fusion, discrete wavelet transform (DWT), high-pass filtering method, directional discrete cosine transform (DDCT) based image fusion [8], [9].
The performance evaluation of the denoising method can be measured by image quality parameters as discussed in [10].

III.PROPOSED METHOD

There has been a rapid growth among the research community to develop a robust and powerful denoising algorithm capable of both edge and feature preservation. In the proposed work, a method of denoising based on multi-sensor image fusion is introduced. The image fusion method is based on a hybrid technique involving the directional discrete cosine transform (DDCT) as well as the principal component analysis (PCM).

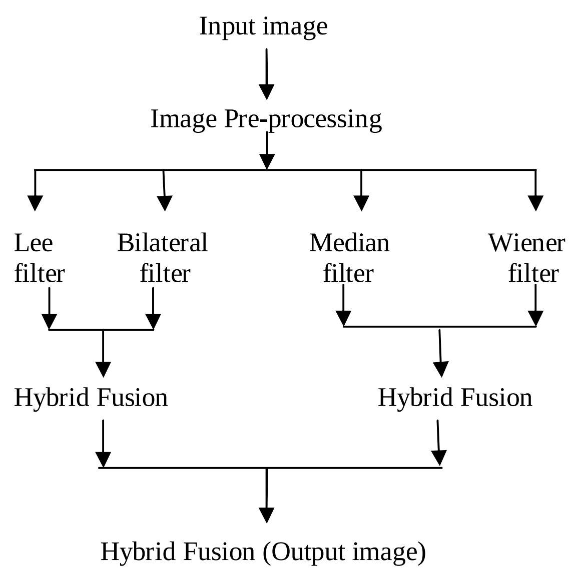

Figure 1: Proposed model

In the first step, an input image of different abdominal is loaded and would be converted to gray scale image format if required for further processing. The second step is image pre-processing, in this step the contrast level of the input image is enhanced because the loaded image may have low contrast level. Aftr this step, the noisy images are subjected to different filters for removing the noise from it. When the images are denoised by these filtering techniques, their respective output images are fused together by using an hybrid fusion algorithm. This image fusion algorithm is based on a combined model (DDCT and PCA). The images to be fused are first divided into non overlapping square blocks and then the fusion process is carried out over these coressponding blocks[11].

The algorithm mainly works in two phases. In the first phase, a total of 9 modes (0 – 8) are performed on the images to be fused. For each mode, the coefficients from these images are used for fusion process and the procedure is repeated for other modes as well. Also, three different fusion rules are used in this fusion process[12] :

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1. Average the corresponding coefficients (DDCTav)

2. Choose the corresponding frequency band with maximum energy (DDCTek)
3. Choose the corresponding coefficient with maximum absolute value (DDCTmx) between the images.

After this step, eight fused images are obtained from each mode respectively. Finally, in the second phase these eight fused images are fused again using the principal component analysis method. Also the performance of this algorithm is evaluated using fusion quality metrics such as root mean square (RMSE), signal to noise ratio (SNR), peak signal to noise ratio (PSNR), mean square error (MSE) and spatial frequency (SF).

IV.PERFORMANCE EVALUATION

The following parameters are used to evaluate the performance of the developed algorithm:

Mean Sqaure Error (MSE) [3,12,13]***:***
The lesser the MSE value between the original image and the output image, better the result. If the MSE value is larger, then the denoising is not reducing noise from the image. It can be mathematically expressed as:

$$MSE = \frac{1}{M \times N}\sum (g(x,y) - f(x,y))^2$$

Signal to Noise Ratio (SNR) [12]***:***
SNR is a common statistical quantity to evaluate the noise reduction effectively. Higher the SNR value indicates the good quality output image. It also indicates that the image has more useful information. Mathematically can be expressed as:

$$SNR \text{ in } dB = 10 \log_{10} \frac{\sigma_f^2}{\sigma_n^2}$$

Where σ_f^2 and σ_n^2 are the values of variances in the image and noise respectively.

Peak Signal to Noise Ratio (PSNR) [12,14]***:***
The PSNR value is the ratio between the maximum possible power of a signal to the power of corrupting noise. Mathematically can be expressed as (in dB):

$$PSNR = 10 \log_{10} \frac{256 \times 256}{MSE}$$

Root Mean Square Error (RMSE) [12,15]***:***
RMSE is computed as the root mean square error of the corresponding pixels in the reference image I_r and the final image I_f. The RMSE value will be zero when the reference and final images are exactly same.

$$RMSE = \sqrt{\frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}(I_r(x,y) - I_f(x,y))^2}$$

Spatial Frequency (SF) [14,16]***:***
Spatial Frequency indicates the overall activity level in the final fused image. It is calculated using both the row frequency and the column frequency. Higher the SF value means better performance.

Row frequency :

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$$RF = \sqrt{\frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=1}^{N-1}(I_f(x,y) - I_f(x,y-1))^2}$$

Column frequency :

$$CF = \sqrt{\frac{1}{MN}\sum_{y=0}^{N-1}\sum_{x=1}^{M-1}(I_f(x,y) - I_f(x-1,y))^2}$$

Spatial frequency :

$$SF = \sqrt{RF^2 + CF^2}$$

V.EXPERIMENTAL RESULTS AND DISCUSSION

This section discusses the experimental results obtained from the proposed algorithm. All the implementation and evaluation work has been carried out in MATLAB 2013. The proposed algorithm is currently applied on an gray scale image with a resolution of 256 x 256 pixels. But can be applied to all sort of medical images such as Ultrasound (US), CT and MRI images affected from speckle noise. The performance measurement was done by calculating some image quality assurance parameters. As mentioned earlier, the proposed method involves few pre-processing steps once the input image is loaded. Then, the image is fed to some filtering techniques and output of each of these filters work as the input for the hybrid technique for fusion of images. Finally we get the fused denoised image with better quality.

Figure 2: Noisy Input image

For visualizing the defects, Figure 2 shows the input noisy image, where the information content is not clearly obtained.

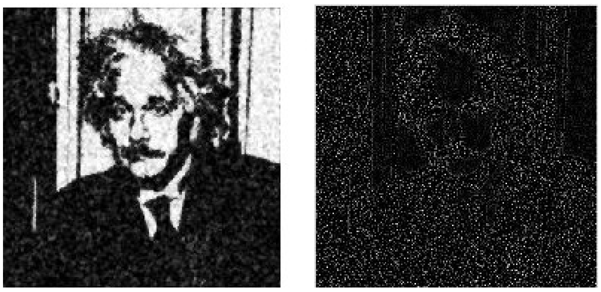

Figure 3: Denoised image and its Error image

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Figure 3, shows the fused image and the error image(fused image subtracted from reference image), with better results.

Table 1: Experimental Results

FILTER	MSE	SNR	PSNR	RMSE	SF	FILTERED IMAGE
Median Filter	0.114	57.551	57.585	0.338	0.236	
Lee Filter	0.112	57.613	57.647	0.335	0.174	
Wiener Filter	0.087	58.726	58.760	0.295	0.252	
Bilateral Filter	0.041	61.923	61.957	0.204	0.077	
Proposed Filter	**0.038**	**62.247**	**62.281**	**0.210**	**0.112**	

For analysing and quantifying its performance some parameters like MSE, SNR, PSNR etc. are calculated. The Quantitative values are presented in Table 1. The metrics showed in table with bold font represent the proposed algorithm and indicate to be better in comparison to the individual filters.

While the present algorithm is carried out, the proposed method presents better results in despeckling medical images as well. Algorithm can be further extended to denoise colour images and images with high resolution thereby obtaining better results in a short span of processing time.

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VI.CONCLUSION

In this paper, a novel and hybrid image fusion method using directional discrete cosine transform and principal component analysis has been presented and its performance is evaluated. It is concluded that filtering process accompanied by this fusion process provides better quality denoised images without losing any useful information. It is very simple, easy to implement and could be used for real time applications.

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BIOGRAPHY

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