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A Performance Analysis of Image De-noising Techniques

R.Sindhuja[1], DR.S.Srinivasan[2]
[1](PhD Student Department of Electronics and instrumentation Engineering, Annamalai University, Chidambaram)
[2](Associate professor, Department of Electronics and instrumentation Engineering, Annamalai University, Chidambaram)
Corresponding Author: R.Sindhuja

ABSTRACT
Image de-noising is a serious challenge in image processing techniques. Noise is broadly categorised as additive and multicative noises. In this paper we will discuss about Gaussian noise, salt and pepper noise, speckle noise and poisson noise. Naturally Images contain some amount of noise. But it's very difficult to denoise it. So blind deconvolution is used. Therefore simulated noise is added to the image to understand the process of denoising. Because after the addition of above mentioned noises if any other transformation or processing is done to the image then the corresponding noises will also be changed. There we will face difficulties to denoise if you don't know the type of noise. So a known noise is added to the image before processing. now let us come to the de-noising methods, Out of different available method wavelet thresholding method is one of the important approaches for image de-noising. In this paper we propose an adaptive method of image de-noising in the wavelet sub-band domain assuming the images to be contaminated with noise based on threshold estimation for each sub-band. Under this framework the proposed technique estimates the threshold level by applying sub-band of each decomposition level. This paper details the development of wavelet decomposition on the MATLAB platform. The experimental result reveals that transform domain is better than the spatial domain which we can prove and analyze through the quality metrics factors.

Keywords - Fingerprint, Image de-noising, Quality metrics, Wavelet transform.

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I. INTRODUCTION

There are many factors that cause noise in digital pictures. That occurs throughout image acquisition, conversion and transmission. Noise classified as follows

1.1 Gaussian noise: is a statistical noise [1] having a probability density function (PDF) equal to that of the normal distribution, which is also known as the Gaussian distribution. In other words, the values that the noise can take on are Gaussian-distributed

1.2 Speckle noise: Speckle is also known as 'granular 'noise' that inherently exists in and degrades the quality of the radar, synthetic aperture radar (SAR), medical ultrasound and optical coheren tomography image.

1.3. Salt and pepper noise: is also called impulse noise, and it occurs due to errors in data transmission. In Gray Image similar to fingerprint a and b value is 0 and 255 respectively. The probability of each is normally less than 0.1... The salt and pepper noise is generally caused by not working of pixel elements in the camera sensors, defective memory locations, or timing inaccuracies in the digitization process

1.4. Poisson noise: shot noise is a type of electronic noise that occurs when the finite number of particles that carry energy, such as electrons in an electronic circuit or photons in an optical device, is small enough to give rise to detectable statistical fluctuations in a measurement.

II. IMAGE DE-NOISING TECHNIQUES:

There are different kinds of image denoising algorithms. They can be broadly classified into two classes:

• Spatial domain filtering
• Transform domain filtering

As the name indicates,[2] spatial domain filtering refers to filtering in the spatial domain, while transform domain filtering refers to filtering in the transform domain.

Image denoising algorithms which use wavelet transforms come under transform domain filtering.

Spatial domain filtering can be further divided into

• Linear filters
• Non-Linear filters

An example of a linear filter is the Wiener filter in the spatial domain. An example of a non-linear filter is the median filter. Median filtering is very useful in getting rid of Salt and Pepper type noise. Spatial filters tend to cause blurring in the denoised image. Transform domain filters causes Gibbs oscillations in the denoised image. Transform domain filtering can be further divided into two broad classes namely

- Fourier transforms filters
- Wavelet transforms filters

III. SPATIAL FILTERING

3.1. Linear filter: Linear filtering is carried out by convolving the input image with a filter function to obtain the filtered image. A linear filter can be written as follows (Marques 2011):

$$F(x,y)=\sum I(m,n).w(x-m,y-n)........(1)$$

Here, I is represents the original input image, f is represents the filtered pixels value, and w is represents the filter coefficients The mean filter, also known as an averaging filter, is an good example of a simple linear filter. It operates by assigning the average value of all pixels in the neighborhood of the input pixels to the corresponding pixel in the output image. The principle of this filter matches perfectly with it name, as each pixel in the targeted image is replaced with the mean value of pixels surrounding it. The mathematical formula for the mean filter (Marques 2011) is given below

$$F(x,y)=1/mn \sum I(m,n)……(2)$$

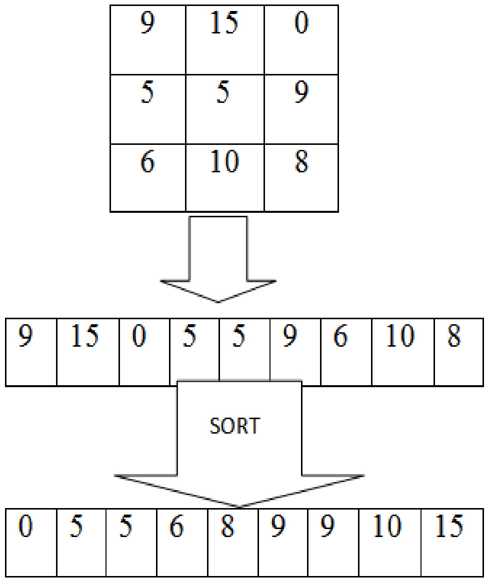
Where: I = the noisy image, f = the restored image and (m, n) = the row and column coordinate respectively, within a window W of size m x n where the operation take places centered on input pixels at (x, y) . For example, if a 3 x 3 window is used, the averaging operation uses the following 3x3mask,

$$1/9\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

3.1.1 Wiener Filter: in the spatial-domain filter and it generally used for suppression of additive noise. Norbert Wiener proposed the concept of Wiener filtering in the year 1942. There are two methods: (i) Fourier-transform method (frequency-domain) and (ii) mean-squared method (spatial-domain) for implementing Wiener filter. The fourier method is used only for denoising and deblurring. Whereas the later is used for denoising. In Fourier transform method of Wiener filtering requires a priori knowledge of the noise power spectra and the original image. But in latter method no such a priori knowledge is required. Hence, it is easier to use the mean-squared method for development. Wiener filter is based on the least-squared principle, i.e. the this filter minimizes the mean-squared error (MSE) between the actual output and the desired

3.2 .NON-LINEAR FILTER: One type of nonlinear filter operates by ranking the pixels in the specified neighborhood. It replaces the target pixel by a value corresponding to the chosen rank. The rank value could be maximum, minimum or middle value in the neighborhoods pixels. In this project, the median filter will be used as an example of nonlinear filter. It used the middle value in the neighborhood of the target pixel.

The median filter is a good example of a nonlinear filter that is used in image processing. The median filter overcomes one of the limitations of the mean filter, which is its inability to reduce impulsive noise. The median filters are also useful in preserving edges of an image while reducing the image noise.



IV. TRANSFORM FILTERING

4.1. Discrete wavelet transform: Wavelet has ability to examine signals simultaneously in both time and frequency domain. Any image decomposition using wavelet has two function that is wavelet function and scaling function

Wavelet play a vital role not only in the theoretical but also in many kinds of applications, and have been widely used such as signal processing, sampling, coding and communications, filter bank theory, system modeling, and so on.

In order for better understanding it is good to see the historical context. The wavelet transform was originally introduced in geophysics by Morlet, and was basically a Gabor transform with a Window that grows and shrinks together with the selected scale/frequency. Later Daubchies (a physicist-ett from Belgium) realized that by choosing special orthogonal wavelet bases the infinitely redundant CWT can be critically sampled on a dyadic grid. From the resulting DWT the corresponding full CWT can be obtained by convolving the DWT with the reproducing kernel of the respective wavelet. The reproducing kernel is the CWT of the wavelet itself.

Daubchies[3] findings gave a very big boost to the wavelet theory in the early 1980. The next big result was that the DWT can be computed very efficiently (this is sometimes called FWT [fast WT] as well) by using techniques from the theory of filterbanks, namely quadrature mirror filters (QMF) together with downsampling filterbanks. By constructing special QMFs the corresponding DWT can be computed via filtering and downsampling, which is the state-of-the-art algorithm to compute DWTs today. You do not need the scaling function to compute the DWT, it is just an implementation detail that FWT process.

Concerning the application side the CWT is the more ideal candidate for signal or time series analysis due to its more fine grained resolution and is usually chosen in most tasks e.g. singularity detection. The DWT is more in the context of fast non redundant transforms. The DWT has a very good energy and thus very much useful for lossy compressions and signal transmissions. There are many wavelets which are used for decomposition as well as for de-noising of images and signals. The important family of wavelet is Haar, daubechies, biorthogonal, coiflet, symlet and dmey. The description of this

A. Haar Wavelet

A Haar wavelet is one of the oldest and simplest type of wavelet. The Haar Transform provide prototype for all other wavelet transforms. Similar to other wavelet transforms, the Haar Transform decomposed the discrete signal into two sub-signals of half its length.The advantage of Haar wavelet is that it is fast, memory efficient and conceptually simple.

B. Daubechies Wavelet

Daubechies wavelet is the first wavelet family which has set of scaling function which is orthogonal. This wavelet has finite vanishing moments. Daubechies wavelets have balanced frequency responses but nonlinear phase responses. Daubechies wavelets are useful in compression and noise removal of audio signal processing because of its property of overlapping windows and the high frequency coefficient spectrum reflect all high frequency changes.

C. Symlet Wavelet

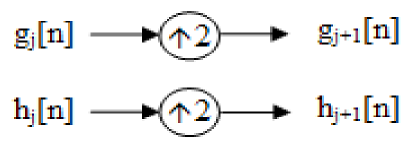
Symlet wavelet provides highest number of vanishing moment and it is compactly supported wavelet. By using symlet wavelet discrete and continuous wavelet transforms are also possible

D. Coiflet Wavelet

Coiflet wavelets are compactly supported wavelet with highest number of vanishing moments for a given support width.

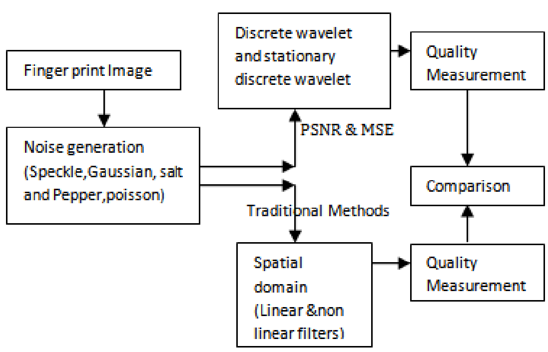
4.2.Stationary Discrete wavelet transform:

The Stationary Discrete wavelet [4] transform (SDWT)[is a wavelet transform designed to overcome the lack of translation-invariance of the discrete wavelet transform (DWT). Translation-invariance is achieved by removing the downsamplers and upsamplers in the DWT and upsampling the filter coefficients by a factor of in the th level of the algorithm. [The SWT is an inherently redundant scheme as the output of each level of SWT contains the same number of samples as the input – so for a decomposition of N a level there is a redundancy of N in the wavelet coefficients.



Swt filters
In the above diagram, filters in each level are up-sampled

V. BLOCK DIAGRAM



VI. IMAGE QUALITY METRICS

PSNR: The PSNR [5] computes the peak signal-to-noise ratio, in decibels, between two images. This ratio is often used as a quality measurement between the original and a compressed image. The higher the PSNR, the better the quality of the compressed or reconstructed image.

MSE: The MSE represents the cumulative squared error between the compressed and the original image, whereas PSNR represents a measure of the peak error. The lower the value of MSE, the lower the error.

VII. SIMULATION RESULTS

With 20 DB SNR added to the input image at level 1 decomposition

Discrete wavelet transform	PSNR	SNR	MSE
Db1	34.49	33.64	0.0003
Db2	34.49	33.64	0.0003
Db3	34.79	33.94	0.0003
Sym3	34.79	33.94	0.0003
Co.if2	34.98	34.09	0.0003
Bior 2.2	35.09	34.23	0.0003

With 20 DB SNR added to the input image at level 1 decomposition

SDWT	PSNR	SNR	MSE
Db1	36.07	35.22	0.0002
Db2	36.07	35.22	0.0002
Db3	36.21	35.35	0.0002
Sym3	36.21	35.35	0.0002
Co.if2	36.19	35.34	0.0002
Bior2.2	36.37	35.52	0.0002

Spatial filtering denoising process:

Spatial (linear&non.linear)	PSNR	SNR
Mean filter	29.29	28.31
Median filter	27.22	26.34
Wiener filter	18.17	16.88

Fig 1. Gaussian noise

Fig 2. Speckle noise

Fig 3. Salt and Pepper noise

Fig 4. Poisson noise

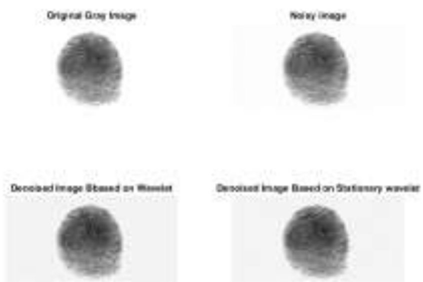


Fig 5. SNR 20db Bi-or2 denoising image at level 1 decomposition

VIII. CONCLUSION:

By Using Dwt and sdwt method one can get best suitable wavelet for particular image that means the wavelet which gives maximum PSNR for particular image. From the experimental results we conclude that sdwt by biorthogonal wavelet which gives maximum PSNR nothing but gives more clarity image as stated abovein fig5.so we can picture out transform filtering is better than spatial filtering methods.

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