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Review of Various Image Restoration and Denoising Methods Underwater Images

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ABSTRACT - The paper presents a denoising method, based on Daubechies Wavelet transform and filters, for underwater images. The method here adapts itself to various types of image noise as well as factor that are to be derived to estimate the noise-free coefficients. In the preference of the images in any field, a single parameter can be used to balance the preservation of relevant details against the degree of noise reduction. Edges play a important role in image representation, one effective means to enhance spatial resolution is to enhance the edges. DWT, a time-scale representation of the digital signal is obtained using digital filtering techniques. Effectiveness of this method is compared with all other techniques such as median ,wiener, bayes shrink and normal shrink methods for removing noise.This paper presents a review of some significant work in the area of denoising. We will introduce the wavelet and other filters methods with homomorphics filters multi-scale analysis framework and summarize related research work in this area.

Keywords— Despeckling, Denoising, DWT, PSNR, MSE and Coc.

1. INTRODUCTION

Image restoration is an art to improve the quality of image via estimating the amount of noises and blur involved in the image. With the passage of time, image gets degraded due to different atmospheric and environmental conditions, so it is required to restore the original image using different image processing algorithms. There is a wide spread application of image restoration in today's world. Application area varies from restoration of old images in museum and radar based image acquisition and restoration.

Image denoising is a necessary step in image processing applications. In brief, all these algorithms first perform the wavelet transform of the image to denoised, apply some filter to the wavelet coefficients, and finally take the inverse wavelet transform to restore the denoised image. Most popular wavelet-filtering algorithms are based on thresholding.

Wavelet analysis has been demonstrated to be one of the powerful methods for performing image noise reduction. The procedure for noise reduction is applied on the wavelet coefficients obtained after applying the wavelet transform to the image at different scales. The motivation for using the wavelet transform is that it is good for energy compaction since the small and large coefficients are more likely due to noise and important image features, respectively. The small coefficients can be threshold without affecting the significant features of the image. In its most basic form, each coefficient is threshold by comparing against a value, called threshold. If the coefficient is smaller than the threshold, it is set to zero; otherwise it is kept either as it is or modified. The inverse wavelet transform on the resultant image leads to reconstruction of the image with essential characteristics.

Image denoising is a fundamental process in image processing, pattern recognition, and computer vision fields. The main goal of image denoising is to enhance or restore a noisy image and help the other system (or human) to understand it better. Image denoising is used to remove the noise while retaining as much as possible the important signal features. The purpose of image denoising is to estimate the original image form the noisy data. Image denoising is still remains the challenge for researchers because noise removal introduces artifacts and causes blurring of the images.

2. LITERATURE SURVEY

Biswa Ranjan Mohapatra (2014), author presents here that Image restoration is an art to improve the quality of image via estimating the amount of noises and blur involved in the image. This paper gives a review of different image restoration techniques used. But primarily image restoration is done mostly using Weiner filter, Richardson-Lucy Blind Deconvolution algorithm, Inverse and Pseudo-inverse filter. [1] **Sarabjeet Kaur (2014),** In this paper, author writes brief introduction of digital image processing related to image restoration, different types of noises are introduced and different methods which are used to remove noise are described with different parameters performed on medical images. Parameters like Contour plots, Histogram equalization, MSE, PSNR, max difference, avg difference, normalized cross correlation, normalized absolute error, structure content are performed to be measured. Salt n pepper noise can be better removed by median filter. The performance of clahe and histogram filter is not better as compare to median, adaptive and linear filter. [2] **Anamika Maurya,(2014),** here author describes about image restoration which estimate the original image from the degraded data by using Different types of image restoration techniques like wiener filter, inverse filter, regularized filter, Richardson –Lucy algorithm, neural network approach ,wavelet based approach, blind deconvolution are described and strength and weakness of each approach are identified.[3] **P. Sureka (2013),** here author described that Image restoration technique which restore the degraded face images such as faxed images, scanned passport photos and printed images by removing noise in the image. The degradations include half toning, dithering and security watermarks. An iterative image restoration scheme is used to restore the severely degraded face images which improve the recognition performance and the quality of the restored image. Here performed the Viola and Jones face detection algorithm which is to localize the spatial extent of the face and determine its boundary. In next step, geometric normalization is applied to both original and degraded images. It holds two processes namely automatic eye detection and affine transformation that matches the images in the database and constructs the canonical faces. Low pass filtering is done using Wiener filter which reduces the noise in the image and the invariant wavelet transform reduces artifacts. Then, the quality of the image is checked using some of the quality metrics and it is restored if the quality is good. Image identification before and after restoration is achieved using certain classification tools and methods. The proposed method of restoration methodology consists of iterative method to restore the noisy images and that is compared with the high resolution counterparts. Their proposed work uses neural network classifier to recognize the image which is restored with that of the original image. Experimental results show that the face recognition is achieved better in neural network classifier than that of k-nearest neighbor classifier used in the existing model. One of the possible improvements could be made is the use of super-resolution algorithm which helps to know about the prior on the spatial distribution of the image gradient for frontal face images. Another future work to be done is the better classification of the degraded face images which will improve the integrity of the overall restoration technique [5]. **Seema, Meenakshi Garg (2014),** here the concept of removing the noises by using the various types of filters and techniques are proposed. A new method based on discrete wavelet transforms using the bayes-shrink method results were compared with median and wiener filter. In this, proposed technique work with two noises, namely Salt &Pepper and Gaussian noise, that were simultaneously reduced from a single image successfully and results were found to be better than wiener and median filters due to better PSNR ratio and Coc value. Results revealed that the proposed method was very efficiently able to remove noise from ultrasound gray scale images then others [6].

3. TYPES OF NOISES

We have implemented 3 types of noise in this our work:

- Gaussian Noise
- Poisson Noise
- Salt and Pepper Noise

1.3.1 GAUSSIAN NOISE.

Any process which may be described in terms of probalistic. In such a process although the details of individual events are unpredictable. Natural process such as rain falling motion of group of insects or birds or the random moments of smoke particles in air may be described as Stochastic. A probability distribution describing random fluctuation is a continuous physical process – KaulFriedric Gaussian.

The distribution described such stochastic process as the random voltage. Variable is a carbon resistor due to thermal motion. When an electrical variation obeys a Guassian distribution, such as in case of thermal motion cited above, it is called Gaussian Noise.

1.3.2 POISSON NOISE

Photon noise, also known as Poisson noise, is a basic form of uncertainty associated with the measurement of light, inherent to the quantized nature of light and the independence of photon detections. Its expected magnitude is signal-dependent and constitutes the dominant source of image noise except in low-light conditions.

1.3.3 SALT AND PEPPER NOISE

Images are often corrupted by impulse noise, also known as salt and pepper noise. Salt and pepper noise can corrupt the images where the corrupted pixel takes either maximum or minimum gray level.

Salt and pepper noise is a form of noise typically seen on images it represent as a randomly occurring black and white pixel. Salt and pepper noise creeps into images in situation where quick transients such as faulty switching take place or caused by malfunctioning pixels of cameras

4. DENOISING METHODS

4.1 Discrete Wavelet Transform

Discrete Wavelet Transform (DWT) is introduced to overcome the redundancy problem of CWT. The approach is to scale and translate the wavelets in discrete steps .

$$\mathrm{DWT}(\tau_0, s_0) = \frac{1}{\sqrt{s_0^f}} \int_{-\infty}^{\infty} f(t)\, \psi\left(\frac{t - k\tau_0 s_0^f}{s_0^f}\right) dt \quad (4.1)$$

Where s_0^f is the scaling factor τ_0 is the translating factor, k and j are just integers.

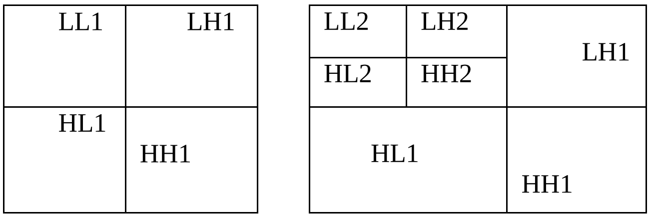
Subsequently, we can represent the mother wavelet in term of scaling and translation of a dyadic transform as

$$\psi_{j,k}(t) = 2^{-f/2} \psi\left(2^{-f} t - k\right) \quad (4.2)$$

Replacing eqn, the coefficients of DWT can be represented as

$$C_{f,k} = 2^{-f/2} \int_{-\infty}^{\infty} f(t) \psi\left(2^{-f} t - k\right) dx \quad (4.3)$$

By applying DWT, the image is actually divided i.e., decomposed into four sub-bands and critically sub sampled as shown in fig 3.1(1):



(a) One-Level (b) Two-Level

Fig 3.1(1): Image Decomposition

4.2. Median Filter

This filter sorts the surrounding pixels value in the window to an orderly set and replaces the center pixel within the define window with the middle value in the set.

$$\hat{f}(x,y) = \underset{(s,t)\in S_{xy}}{\text{median}}\{g(s,t)\} \tag{4.4}$$

4.3. Wiener Filter

Wiener2 low pass-filters an intensity image that has been degraded by constant power additive noise. Wiener2 uses a pixel wise adaptive Wiener method based on statistics estimated from a local neighborhood of each pixel.

J = wiener2 (I, [m n],noise) filters the image I using pixel wise adaptive Wiener filtering, using neighborhoods of size m-by-n to estimate the local image mean and standard deviation. If you omit the [m n] argument, m and n default to 3. The additive noise (Gaussian white noise) power is assumed to be noise.

[J, noise] = wiener2 (I, [m n]) also estimates the additive noise power before doing the filtering. Wiener2 returns this estimate in noise.

4.4 Bayes Shrink Thresholding Method

Bayes Shrink was proposed by Chang, Yu and Vetterli. The goal of this method is to minimize the Bayesian risk, and hence its name, Bayes Shrink The Bayes threshold, is defined as:

$$\mathbf{t_B} = \boldsymbol{\sigma}^2/\boldsymbol{\sigma_s} \tag{4.5}$$

The noise variance is estimated from the sub band HH by the median estimator. From the definition of additive noise we have w(x,y) = s(x,y)+n(x,y). Since the noise and the signal are independent of each other, it can be stated that can be computed as shown below.

With and the Bayes threshold is computed from

$$\boldsymbol{\sigma_w^2} = \boldsymbol{\sigma_s^2} + \boldsymbol{\sigma^2}.$$

σ_w^2 can be computed as shown below:

$$\boldsymbol{\sigma_w^2} = \frac{1}{n^2}\sum_{x,y-1}^{n} \mathbf{w}^2(\mathbf{x},\mathbf{y}).$$

The variance of the signal, σ_s^2 is computed as

$$\boldsymbol{\sigma_s} = \sqrt{\max(\boldsymbol{\sigma_w^2} - \boldsymbol{\sigma^2}, \mathbf{0})}. \tag{4.6}$$

Using this threshold, the wavelet coefficients are threshold at each band.

4.5 Normal Shrink Thresholding Method

Normal Shrink is an adaptive threshold estimation method for image denoising in the wavelet domain based on the generalized Gaussian distribution (GGD) modeling of sub-band coefficients. It is computationally more efficient and adaptive because the parameters required for estimating the threshold depend on sub-band data.

The steps of Normal Shrink for image denoising are as follows:

1) Take the logarithmic transform of the speckled image.
2) Perform multi-scaled decomposition of the image corrupted by Gaussian noise using wavelet transform.
3) Estimate the noise variance σ^2 from subband HH1 using formula:

$$\hat{\sigma}^2 = \left[\frac{median(|Y_{ij}|)}{0.6745}\right]^2, \qquad Y_{ij} \in subband\ HH_1 \tag{4.7}$$

4) For each level, compute the scale parameter β using the equation:

$$\beta = \sqrt{\log\left(\frac{L_k}{J}\right)} \tag{4.8}$$

5) For each sub-band (except the low pass residual) :

a) Compute the standard deviation σ_y.
b) Compute threshold T_N using equation

$$T_N = \frac{\beta\,\hat{\sigma}^2}{\hat{\sigma}_y} \tag{4.9}$$

c) Apply soft thresholding to the noisy coefficients.

6) Invert the multiscaled decomposition to reconstruct denoise image $\hat{f}$.
7) Take the exponential of the reconstructed image obtained from step 6[3].

5. CONCLUSION

This paper presents a various methods for denoising images, as we know that thresholding methods is used to restore images with different noise levels. As seen from the above discussion that wavelet thresholding is an effective method of denoising noisy signals. We first tested hard and soft thresholding on noisy versions of the standard 2-D images. Thus we can implement Bayes thresholding to remove noise from images. These also show good results. We can work on wavelet thresholding and bayes thresholding, for further enhanced of having better noise removal efficiency by adding more restoration techniques like Normal Shrink, Stationary Wavelet Transform (SWT) etc. Also, more wavelet decomposition levels can be used for better parameter performance values.

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