SURE-LET and Wavelet Transform based Image Denoising Methods: A Review

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Abstract- Evaluating the denoising quality is essential to compare various denoising algorithms or to validate a denoising procedure applied on real data. Denoising is an essential step prior to any higher-level image-processing tasks such as segmentation or object tracking, because the undesirable corruption by noise is inherent to any physical acquisition device. When the noise is considered as signal-independent, it is often modeled as an additive independent (typically Gaussian) random variable, whereas, otherwise, the measurements are commonly assumed to follow independent Poisson laws, whose underlying intensities are the unknown noise-free measures. The goal of any denoising algorithm is to find the best estimate of the underlying noise-free signal. The key point is then to quantify how close to the original signal a given estimate is. The SURE-LET can able to transform the unknown weight as well as the quadratic estimation with peak boundary values. The review represents the advancement of the SURE-LET transform based image denoising methods and its advantages of it over classical methods like wavelet.

Keywords- SURE-LET Transform, Wavelet Transform, Image Denoising, Gaussian, Noise.

I. INTRODUCTION

“According to C Liu et. al. Image Noise is a random variation of brightness information in images produced by the sensor and circuitry of a sensor. Image noise can also originate in the unavoidable shot noise of an ideal photon detector”[10] or from the quantization process while Analog-to-Digital (ADC) conversion [11]. Noise is the most difficult specification of sensor, as it is hard to predict in economically feasible manner.

Noise should not be confused with atmospheric errors. Atmospheric errors are mainly due to the atmospheric constituents (Aerosol, Water Vapors, etc.). On the other hand noise is purely due to the sensor and circuitry involved. These errors will always remain independent of atmospheric constituents [11].

The digital sensors converts the incoming irradiance i.e. the photons coming into the imaging sensor, to analog signal and finally to digital signal. Figure 1 depicts the block diagram of the acquisition process. As observed from the diagram there are mainly five noise components acting on the pipeline namely fixed pattern noise, dark current noise, shot noise, amplifier noise and quantization noise [10].

To fulfill the objective of an efficient Image Denoising technique [1] combination of SURE-LET and Wavelet Transform. the hybrid technique of SURE-LET and Wavelet transform is most efficient among the image denoising techniques.

The extraction of information can be significantly altered by the presence of random distortions called noise the type and energy of this noise naturally depend on the way the images have been acquired or transmitted. The observed image usually consists in a 2D array of pixels: for gray-level images, there is only one channel of light intensity measurement, whereas multispectral (e.g. color) images can have several channels (e.g. RGB: red, green and blue). In most imaging modalities, the measurements are usually performed by a charge-coupled device (CCD) camera which can be seen as a matrix of captors. The pixel value at a particular location is given by the number of photons received by the corresponding captor for a fixed period of time. Most of the noise arises from the fluctuation of the number of incoming photons, but additional perturbations are generated by the thermal instabilities of the electronic acquisition devices and the analog-to-digital conversion. Although the amount of noise actually depends on the signal intensity, it is often modeled as an additive independent (typically Gaussian) random variable, especially when the magnitude of the measured signal is sufficiently high.

There are two main approaches to deal with these unexpected, but also unavoidable, degradations. These are often combined to get a safer solution. The first one is to develop analysis tools that will be robust with respect to noise; the second one, which will retain our attention in this exploration, is to perform a pre-processing step that will consist in denoising the data. The trade-off which needs to be optimized is then to reduce the noise level while preserving the key image features.

The vast majority of existing denoising algorithms is specifically designed for the reduction of additive white Gaussian noise (AWGN) in 1D or 2D monochannel data;

this considerably reduces their range of application. In particular, denoising the huge multidimensional datasets.

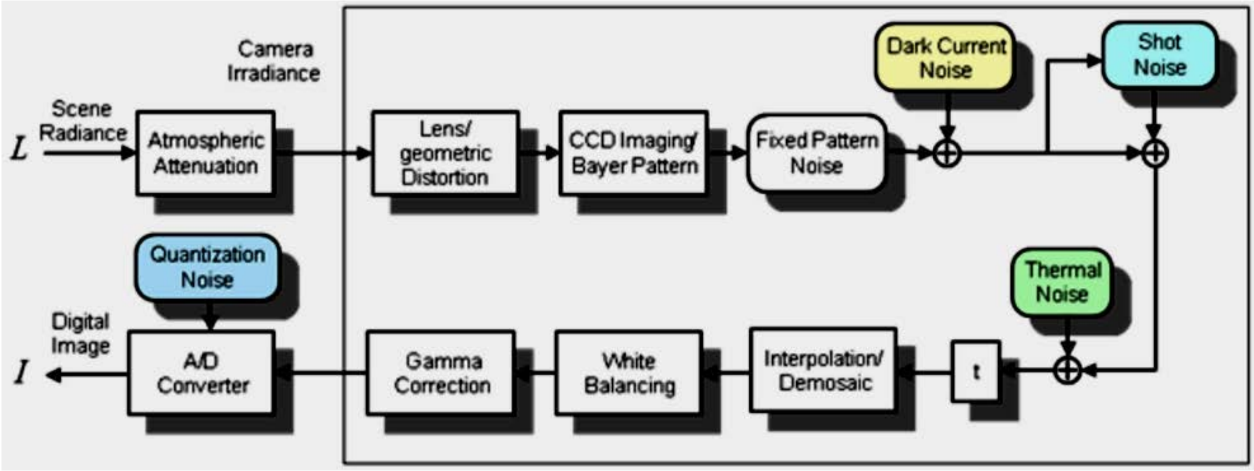

Figure 1.1 Image acquisition process.

II. THEORETICAL BACKGROUND

A linear denoising method based on linear threshold expansion. This approach of image denoising approach provides a minimization of an estimate of the mean squared error--Stein's unbiased risk estimate (SURE). As opposed to hypothesizing a measurable model for the wavelet coefficients, it is ideal to utilize specifically parameterize the denoising process as an aggregate of basic nonlinear courses of action with obscure weights.

A. Wavelet Theory

Wavelet Theory is one of the most modern areas of mathematics. Masterfully developed by French researchers, such as Yves Meyer, Stephane Mallat and Albert Cohen, this theory, is now used as an analytical tool in most areas of technical research: mechanical, electronics, communications, computers, biology and medicine, astronomy an so on. In the field of signal and image processing, the main applications of wavelet theory are compression and denoising.

The term ‘wavelet’ refers to an oscillatory vanishing wave with time-limited extend, which has the ability to describe the time-frequency plane, with atoms of different time supports figure 2.1 demonstrated wavelet of signal. Generally, wavelets are purposefully crafted to have specific properties that make them useful for signal processing. They represent a suitable tool for the analysis of non-stationary or transient phenomena.

Wavelets are a mathematical tool that can be used to extract information from many kinds of data, including audio signals and images. Mathematically, the wavelet ψ, is a function of zero average, having the energy concentrated in time.

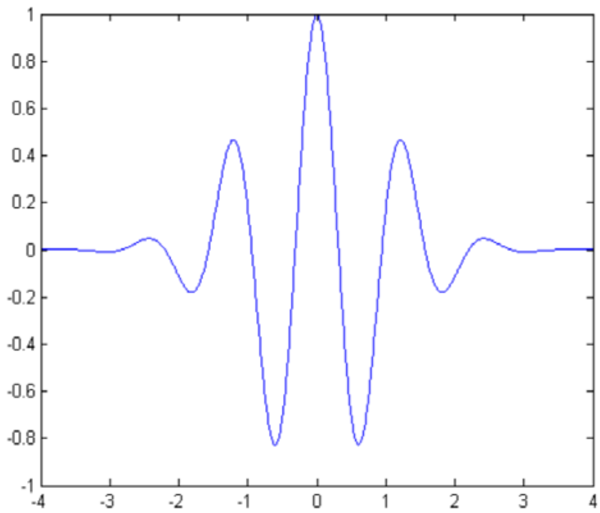

Figure 2.1 Wavelet.

B. SURE-LET

Since do not have access to the original signal x, it cannot compute the above Oracle MSE. However, without any assumptions on the noise-free data, it will see that it is possible to replace this quantity by an unbiased estimate which is a function of y only. This has an important consequence: contrary to what is frequently done in the denoising literature (Bayesian approaches), the noise-free signal is not modeled as a random process in our framework (we do not even require x to belong to a specific class of signals). Thus, the observed randomness of the noisy data only originates from the AWGN b.

SURE is a random variable that has the same expectation as the MSE. Now evaluate its reliability by computing the expected squared error between SURE and the actual MSE. For the sake of simplicity, consider the AWGN model described the mean-squared error (MSE) clearly emerges as the best candidate, due to its appealing mathematical properties (quadratic, symmetric, differentiable, invariant to unitary transforms). and do not take into account the error induced by the estimation of the noise-free signal energy $||x||^2$ because this term does not appear in the minimization of SURE/MSE.

III. RELATED WORK

S. Saxena, H. S. Khanduga, S. Mantri and S. Puri,[1] Our objective of this research is to frame an efficient method based on wavelet so that sparsity and multi-resonate structure of wavelet properties can be used for Image Denosing. So fulfilling the objective to make an efficient Image Denoising technique we have proposed an Image denoising technique which is based on squared error-Stein's unbiased risk estimate linear expansion of thresholds (SURE-LET). This technique is a combination of SURE-LET and Wavelet Transform. This hybrid approach gives good result because the sparsity and multi-resonate properties of wavelet will fetch linear noise less relation matrix as well as related matrix. The SURE-LET can able to transform the unknown weight as well as the quadratic estimation with peak boundary values. The results are calculated and compared with the help of peak signal to noise ratio (PSNR) and mean square error (MSE). The comparative study suggests that our hybrid approach has outperformed from the previous approach.

H. Sadreazami, M. O. Ahmad and M. N. S. Swamy,[2] A new contourlet-based method is introduced for reducing noise in images corrupted by additive white Gaussian noise. This method takes into account the statistical dependencies among the contourlet coefficients of different scales. In view of this, a non-Gaussian multivariate distribution is proposed to capture the across-scale dependencies of the contourlet coefficients. This model is then exploited in a Bayesian maximum a posteriori estimator to restore the clean coefficients by deriving an efficient closed-form shrinkage function. Experimental results are performed to evaluate the performance of the proposed denoising method using typical noise-free images contaminated by simulated noise. The results show that the proposed method outperforms some of the state-of-the-art methods in terms of both the subjective and objective criteria.

H. Sadreazami, M. O. Ahmad and M. N. S. Swamy,[3] Statistical image modeling has attracted great attention in the field of image denoising. In this work, a new image denoising method in the contourlet domain is introduced in which the contourlet coefficients of images are modeled by using the Bessel k-form prior. A noisy image is decomposed into a low frequency approximation sub-image and a series of high frequency detail sub-images at different scales and directions via the contourlet transform. To estimate the noise-free coefficients in detail subbands, a Bayesian estimator is developed utilizing the Bessel k-form distribution. In order to estimate the parameters of the distribution, a characteristic function-based technique is used. Simulation results on standard test images show improved performance both in visual quality and in terms of the peak signal-to-noise ratio and structural similarity index as compared to some of the existing denoising methods. The proposed method also achieves an excellent balance between noise suppression and details preservation.

R. Saluja and A. Boyat,[4] An efficient method of removing noise from the image while preserving edges and other details is a great challenge for researcher. Image denoising refers to the task of recovering a good estimate of the true image from the degraded image without altering and changing useful structure in the image such as discontinuities and edges. Various algorithm has been developed in past for image denoising but still it has scope for improvement. In this research, we introduced an intelligent iterative noise variance estimation system which denoised the noisy image. Proposed algorithm is based on wavelet transform that denoised the noisy image by adding weighted highpass filtering coefficients in wavelet domain that is the novelty of the proposed work. Thereafter denoised algorithm further enhanced by adaptive wiener filter in order to achieve the maximum PSNR. Experimental results show that the proposed algorithm improves the denoising performance measured in terms of performance parameter and gives better visual quality. Mean Square Error (MSE), Root Mean Square Error (RmSE) and Peak Signal to Noise Ratio (PSNR) used as a performance parameters which measure the quality of an image.

M. Arora, S. Bashani, K. K. Gupta and A. M. Mohammed,[5] Even after a phenomenal progress in the quality of image denoising algorithms over the years, there is yet a vast scope of improving the standard of denoised images. This research presents a new methodology for denoising by integrating the wavelet denoising technique with regression boosted trees. Based on ensemble learning by regression boosted trees, an optimal threshold value is obtained. Its denoising performance is better than Stein's unbiased risk estimator-linear expansion of thresholds (SURE-LET) method which is an up to date denoising algorithm. We have also compared its performance with the other current state of art wavelet based denoising algorithms like ProbShrink, and BiShrink on the basis of their Peak Signal to Noise Ratio (PSNR). Simulations and experimentation results demonstrate that PSNR of our proposed method outperforms the other methods. Extension to Dual Tree-Complex Wavelet Transform (DT-CWT) is also presented

Table 1: Summary of Literature Review

Sr. No.	Title	Authors	Year	Methodology	Outcomes (PSNR)
1	An efficient denoising method based on SURE-LET and Wavelet Transform,	S. Saxena, H. S. Khanduga, S. Mantri and S. Puri,	2016	Hybrid technique for image denoising a combination of SURE-LET and Wavelet Transform	33.15dB
2	Image denoising utilizing the scale-dependency in the contourlet domain,	H. Sadreazami, M. O. Ahmad and M. N. S. Swamy,	2015	A non-Gaussian multivariate distribution is proposed to capture the across-scale dependencies of the contourlet coefficients	29.65dB
3	Contourlet domain image denoising based on the Bessel k-form distribution,	H. Sadreazami, M. O. Ahmad and M. N. S. Swamy,	2015	A Bayesian estimator is developed utilizing the Bessel k-form distribution.	33.95dB
4	Wavelet based image denoising using weighted highpass filtering coefficients and adaptive wiener filter,	R. Saluja and A. Boyat,	2015	Introduced an intelligent iterative noise variance estimation system which denoised the noisy image	31.88dB
5	Wavelet denoising: Comparative analysis and optimization using machine learning,	M. Arora, S. Bashani, K. K. Gupta and A. M. Mohammed,	2014	A new methodology for denoising by integrating the wavelet denoising technique with regression boosted trees.	35.25dB

IV. PROBLEM STATEMENT

Beyond the different approach, more recent investigations have shown that substantially larger denoising gains can be obtained by considering the intra- and inter-scale correlations of the wavelet coefficients. In addition, increasing the redundancy of the wavelet transform is strongly beneficial to denoising performance. Among the many denoising algorithms to date, it would emphasize the SURE-LET transform with Wavelet Transform. Collectively to achieve the optimum image noise cancellation.

V. CONCLUSION

Different image denoising techniques and algorithms are used for the reduction and denoising of the image wavelet transform is the most widely used technique for image denoising algorithms. The Discrete Wavelet Transform (DWT). It is made of two trees, both of them implementing a DWT, one applied to the original signal and the other applied to the Hilbert transform of the original signal. The advantage of choosing ADWT over the well-known Dual Tree Complex Wavelet Transform is the possibility to freely choose the mother wavelet from the wide range classically associated with the DWT. the SURE-LET approach to the estimation of Poisson intensities degraded by AWGN. “Poisson’s unbiased risk estimate” (PURE) and requires more adaptive transform-domain thresh-olding rules. SURE-LET and Wavelet Transformation based method are better denoising capabilities as compare to DWT ADWT transforms.

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