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Emerging Trends In Image De-Noising Methods

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Abstract:-Many researches are carried out to remove noise in an image. Various approaches have been proposed each has its own advantages and limitations. Some methods used and some concepts which may be used in future to remove noise is discussed in this paper.

Keywords—Image, Discrete Wavelet transform, UDWT, De-Noising, Gaussian Distribution

I. INTRODUCTION

Noise may induce into the image due to interference of natural phenomenon, data acquisition problems, imperfect instruments, compression and transmissions. Removing of noise from an image is very necessary before it is analyzed .digital images are used in television, satellites, magnetic resonance imaging astronomy, graphical information system etc.

Because noise removal tool introduces defeat such as image blurring de-noising remains a field of research.different Techniques for noise reduction or de-noising is explained in this paper. The figure1 shows an example of denoised image.

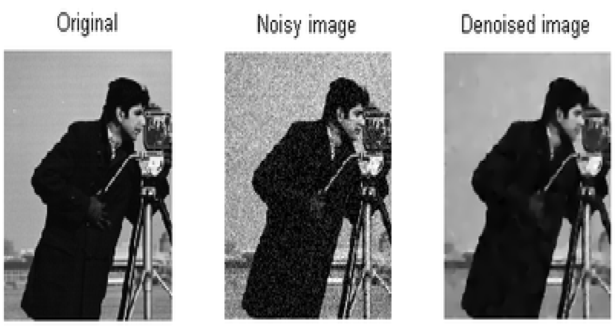

Fig 1. Original image, image with noise ,image after removing noise

Image acquiring device, transmission channel, discrete sources of radiation and image quantization are the factors that affect the Noise modeling. Some images especially ultrasonic images have Gaussian noise[2] and some have Rician noise as in MRI images[3]. With respect to the noise present in an image different algorithm are chosen.

II. EVOLUTION OF IMAGE DENOISE RESEARCH

Images taken from camera will pickup noise this noise has to be removed for aesthetic purpose, artistic work marketing and computer vision. Images are different in color or intensity from their surrounding pixels, if the Noise is Salt and Pepper type. Every pixel in image is altered from initial value with very small difference in Gaussian type Noise. In selecting a reduction algorithm. One must check for following factors

a) The power available and time limit. Desktop computers have more power and the limit where as dial camera should use less power on board and should be fast.
b) Whether same real details in an image can be sacrificed so that more noise can be removed or the information in the image is unaltered.
c) The detail of the image and characteristic of the noise in it.

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Wavelet transform plays an important role in removing noise specially Gaussian .this paper summarize different techniques for removing noise from an image .

III. CLASSIFICATION OF DENOISE ALGORITHM

The spatial domain filtering and Transfer domain filtering are two basic methods for removing noise from an image.

Spatial filter is traditional method of denoising; it can be classified into linear filter and nonlinear filter.

Linear filter used to filter Gaussian noise is mean filter. Image .fine details such as sharp edges lines blurred and in presence of signal dominant noise performance is poor for this method. Wiener filter [11] approach is another linear filter which requires information of original image and spectra of the noise.

Wiener filter uses spatial filtering and its design complexity depends on choice of window size. Wavelet based de-noising algorithms are proposed by Johnston and Donoho [12, 13] to reduced the limitations of wiener filtering.

In nonlinear filtering approach doesn't tries to clearly identify noise in image. Spatial filter uses low pass filtering with assumption that higher frequency spectrum of the image is occupied by noise. Spatial filter remove noise to resonable extent. But image is blurred and because of this edge in image becomes invisible relaxed median [10], rank selection [9] and weighted median [8] has been proposed in recently so that drawbacks explained above can be handled.

Transform domain filtering technique can be classified into Non-adaptive and adaptive transforms depending on the basis function chosen.

Fast Fourier transform is used by spatial filtering to design a low pass filter. In any frequency domain method first a filter is designed and a cutoff frequency is adapted so that noise can be detached from the original information signal. The drawbacks of this method are it is time consuming and introduce additional frequencies in the image which is in process.

In wavelet domain the filtering can be nonlinear and linear or nonlinear. In linear filtering method, filters such as Wiener filter give best results in the wavelet domain. If we consider mean square error (MSE) as criteria for accuracy [14, 15] and Gaussian process is used for modeling signal corruptions. Based on this assumption the filter is designed, it results in an image which is not pleasing compared to the original image with noise, even after filtering with less MSE. Wiener filter is applied only within each scale instead of inter scale in a wavelet domain especially adaptive FIR [16].

Using wavelet domain can convert white noise from spatial domain to transform domain ,this property is used in non linear threshold filtering In transform domain signal coefficients are concentrated within fewer components but noise coefficients are not. Using this concept noise can be separated from message signal.

The method in which coefficients with only small value is removed while remaining are unaltered is called Hard thresholding. But removing moderate and coefficients with larger noise value generates artifacts. Soft thresholding was also proposed or introduced to rectify the drawbacks of hard threshold method. In this method coefficients whose values are above threshold are reduced by the magnitude of threshold itself .some other methods are semi soft threshloding and, garrote thresholding. Non adaptive thresholding technique depends on the number of data points ,as in VISUShrink[12]. Best performance can be achieved if the number of pixels is very large in terms of MSE.

Adaptive thresholding for example SUREshrink [12] uses a combination of SURE and Threshold and is better than VISUShrink and Bayesshrinks[17,18]. Data adaptive threshold can be obtained by assuming generalized Gaussian prior ,in Bayesshrinks method .Bayesshrinks performance is more compared to SUREshrink.

Each wavelet coefficients replaced by neighborhood coefficients weighted average in order to minimize generalized cross validation (GSV) function so that threshold will be optimal for every coefficient.

Assumption is made that signal coefficient magnitude is more compare to noise coefficient magnitude while separating signal from noise is not valid if noise coefficient magnitude are higher than signal coefficient magnitude. During this condition where noise value is high the spatial pattern of the neighboring coefficients will be helpful such as line curve etc, while noisy coefficient just randomly scattered.

Non orthogonal wavelet such as UDWT is used to get better solution visually by separating the components of the signal.UDWT avoids visual artifacts like pseudo Gibbs phenomenon because it is shift invariant .Because UDWT increases complexity of computations this method become less convenient. Shift invariant Discrete wavelet transform is extension of normal soft and hard thresholding[20]. Basis function (21) can be obtained by

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Shift Invariant wavelet packet decomposition (SIWPD).Best Basis functions are identified by using minimum description length principle which result in description of data using smallest length.

Use of Multi wavelets in addition to UDWT further increases the performance but computational complexity also increases. Vanishing moments in higher order symmetry and short support are the properties of multi wavelets. Multi wavelets can be obtained by applying many scaling function on data set excellent results are obtained in case of Lena image with respect to MSE if we take combination of shift invariance and multi wavelets.

Wavelet coefficient model approach uses multi resolution property of wavelet transform. This method gives strong relationship or connection of signal at different resolutions. Even though this method is expensive and complex it provides better performance.

Wavelet coefficient modeling can divided into deterministic or statistical. In deterministic modeling with each level indicating a scale of transform and nodes of wavelet a tree is structured [23]. The hierarchical explanation of wavelet disintegration is displayed if the tree approximation is optimum. Wavelet coefficient which are singular have large wavelet coefficients and they keep on along the branched of tree .In case of signal wavelet coefficient should have its strong presence particular mode and consistent more noticeable at its parent node. Consistence presence is missing if the coefficient is noisy.

Donoho [25] proposed a method for removing noise which is based on wavelet coefficient tree. In scale space local maxima is tracked by LU et al [24] by using tree structure. Statically modeling of wavelet coefficients method concentrate on wavelet transform like local correlation between neighboring coefficients , multi scale correlation between wavelet coefficients ,marginal probabilistic model and joint probabilistic model. Based on a probabilistic model it uses the statistical properties of the wavelet coefficients.

Local probability models which are homogeneous models developed by many researchers. The marginal distribution has coefficients of wavelet with marked peak at heavy tails and the commonly used method to model distribution of wavelet coefficients are Gaussian distribution model (GGD) and Gaussian mixer distribution model (GMM)[28,29] . GGD is more accurate but GMM is simpler. In one of the work [30] proposed the wavelet assume that zero mean Gaussian variables are conditionally independent, highly correlated random variable with variance modeled as identically distributed .marginal prior distribution of wavelet coefficient variable is estimated by maximum A posterior(MAR) probability rule. Noise estimate is required in all these above mentioned methods which is practically difficult to obtain. Two parameter generalized laplacian distribution is used by Simoncelli and Adelson estimated wavelet coefficients of image from noisy observation. Adaptive wavelet thresholding method can be used to do image denoising in which wavelet coefficients are generalized as random variables. It proposed by Chang et al [31].

Random Markov field and Hidden Markov models (HMM) are examples of joint probabilistic model .intra scale coefficients can be efficiently captured by this methods and be . Higher order statistics can be modeled by using HMM. Correlation between coefficients residing in close neighborhood but at same scale can be modeled by using Hidden Markov model chain. Hidden Markov trees are used to model relationship between coefficients across the maximization chain is used to calculate the required parameter for the relationship captured by HMM. MAP estimator is used to remove the noise form signal using obtained parameters.

Product of an hidden random scalar multiplier and independent Gaussian random vector gives Gaussian scale mixture (GSM) which describes the neighborhood of wavelet coefficients in [31]. A another method proposed by Jansen and Bulthel which uses marko random field model for wavelet coefficients a uHMT [27] which is a simplified HMT was proposed so that it can overcome the training stage computational complexity in HMT.

Independent Component Analysis which are Data adaptive transform used for denoising non Gaussian data was implemented successfully. This method can be used to denoise images with and without Gaussian distribution because it assumes signal to be Gaussian which is advantage compare to other method. ICA requires samples of at least two image frames of same scene without noise or noise free data but it is difficult to obtain the training data without noise. As it uses sliding widow the computational cost is also higher compare to wavelet based methods these are two drawbacks of this method.

CONCLUSION

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The assumption that the noise model to be Gaussian is done by many existing techniques but this assumption may not holds good in reality. An ideal denoising technique requires prior information of noise in image but practically it is difficult to have the information of noise model or noise. Almost all algorithm uses noise model or known variance of noise to compare the performance with other algorithm. Denoising algorithm performance is measured using signal to noise ratio (SNR) or Peak signal to noise ratio (PSNR). Many researchers do not uses noise variance comparable to signal strength to test the performance.

Wavelet transform has high performance compare to FFT because of its multi resolution, multi scale nature like properties. Sparsely FFT has limitation that it has spare representation of data. Computational complexity also to be considered along with performance .Thresholding technique with DWT is easy to implement .multi wavelet and UDWT improve the performance but add increases computation complexity. HMM method complex but seems to be perfect. Selection of scale level at which thresholding begin and choice of analyzing wavelet has large influence on success of shrinkage procedure success is influenced by choice analyzing wavelet and selection of the scale level at which thresholding begin.

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