Proc. of Int. Conf. on Emerging Trends in Engineering & Technology, IETET

Image De-noising Techniques: A Review Paper

Sangeeta Rani[1], and Pankaj Dev Chadha [2]
[1]Research Scholar, Master of Technology, Department of Computer Engineering, GIMT, KKR, India
E-mail:-sangeetakkr30@gmail.com
[2]Assistant Professor, Department of Computer Engineering, GIMT, KKR, India
E-mail:-pankaj@gimtkkr.com

***Abstract*—The Image denoising remains a challenge for researchers because noise removal introduces artifacts and causes blurring of the images. Image sensors collect the data sets which are contaminated by noise due to imperfect instruments; disturbed natural phenomenon can also degrade the quality of data of interest. Noise can also be introduced in images due to transmission and compression of images. In this paper we introduce some different type if noise that is Gaussian noise AWGN, Impulsive noise etc. So, it is necessary to depute some effective image denoising techniques to prevent this type of corruption from digital images. There are numerous techniques available for the purpose. There are two fundamental approaches to image denoising Spatial domain filtering, Transform domain filtering. These approaches are further divided into linear, non linear, FFT, UDWT etc. The future scope after reading these technique is to Denoising image by treated the image's pixels and its neighbors as vector variables whose training samples are selected from local windows using block matching based LPG. This ensures only the similar samples are selected for the PCA transformation so that the desired local characteristics are only preserved with considerable noise reduction. The LPG –PCA algorithm is performed twice to enhance the quality of an image.**

***Index Terms*— Image denoising, Principal component analysis, Spatial Filters, transform filters.**

I. INTRODUCTION

Everywhere we are faced with pollution. This does not even leave images when we communicate capture, store or work on them. This pollution of images is called Noise. Researchers are facing a big challenge while dealing with such contaminated images. A reverse process has to be applied to remove this noise and this noise removal process is called Denoising. Extensive work has been done in this area and we come across sea information about the techniques that have been proposed, worked upon and implemented to denoise images. Besides the noisy image produces undesirable visual quality, it also lowers the visibility of low contrast objects. Hence noise removal is essential in digital imaging applications in order to enhance and recover fine details that are hidden in the data. In many occasions, noise in digital images is found to be additive in nature with uniform power in the whole bandwidth and with Gaussian probability distribution. Such a noise is referred to as Additive White Gaussian Noise (AWGN). It is difficult to Suppress AWGN since it corrupts almost all pixels in an image. The rest of this paper is organized as follows. Section 2 outlines the image denoising including types of noise and some noise filtering techniques. Then, Sections 3rd and 4thdiscuss, in

Grenze ID: 02.IETET.2016.5.6

brief the need for edge preservation and detection and literature review of the denoising techniques in each domain. The last section consists of the conclusion.

A. Types of Noise

Gaussian noise:- The one of the most occurring noise is Gaussian noise. Its main sources of Gaussian noise arise during acquisition e.g. sensor noise caused by poor illumination and transmission e.g. electronic circuit noise. Gaussian noise represents statistical noise having 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.

Impulsive Noise:- The other name of impulsive noise is salt-and- pepper noise or spike noise. This type of noise is usually seen on images. It contains white and black pixels. An image containing salt and pepper noise consists of two regions i.e. bright and dark regions. Bright regions have consists of dark pixels whereas dark regions have consists of bright pixels.

Speckle Noise:- The other name speckle noise is multiplicative noise. It is a granular noise. It commonly exists in and the active radar and synthetic aperture radar (SAR) images. It increases the mean grey level of a local area. It causes difficulties for image analysis in SAR images .It is mainly due to the coherent processing of backscattered signals from multiple distributed targets.

B. Denoising Techniques

Denoising is the process of removing the inherent noise from a given image. There are many techniques available for this purpose. The selection of these techniques depends on the type of image & the noise model present in that image. There are two fundamental approaches to image denoising:

Spatial domain filtering

Transform domain filtering

Spatial Domain:-In this domain various filters like mean filter, median filter, all work directly on the input image. Spatial domain directly works on the pixels of the original image. Among various spatial based filters, wiener filter gives best performance in the case of Gaussian, Poisson and speckle noise. In case of impulse noise, median filter outperforms all other filters. Various enhanced median filters are also used for this purpose for eg weighted median filter. Spatial filters are a traditional way to remove noise from image. Spatial filters can be further classified into non-linear and linear filters.

Non-Linear Filters:-In non-linear filters, the noise is removed without any attempts to explicitly identify it. Spatial filters employ a low pass filtering on groups of pixels with the assumption that the noise occupies the higher region of frequency spectrum. Generally spatial filters remove noise to a reasonable extent but at the cost of blurring images which in turn makes the edges in pictures invisible. In recent years, a variety of nonlinear median type filters such as weighted median, rank conditioned rank selection and relaxed median have been developed to overcome this drawback.

Linear Filters:- A mean filter is an optimal linear filter for Gaussian noise in the case of mean square error. Linear filters tend to blur sharp edges, destroy lines and other fine image details, and perform poorly in the presence of signal-dependent noise.

Transform Domain:-Transform domain is necessary to analyze the signal. Transform domain transform the given signal to another domain and do the denoising procedure there and afterwards inverse of the transformation is done in order to get final output. There are several transforms available like the Fourier transform, Hilbert transform, wavelet transform, etc. The Fourier transform is the most popular transform. One of the different Fourier transforms fast Fourier Transform (FFT) is considered the best. However the Fourier transform does not give high performance in case of image denoising. Wavelet transform is better for this purpose. Wavelet transform provide different methods to remove noise from an image which includes thresholding non- orthogonal wavelet transform and coefficient model. Its filtering methods can be subdivided according to the choice of the basic functions. The basic functions can be further classified as data adaptive and non-adaptive. Non-adaptive transforms are discussed first since they are more popular.

Spatial-Frequency Filtering:-Spatial-frequency filtering has used low pass filters using Fast Fourier Transform (FFT). In frequency smoothing methods the removal of the noise is achieved by designing a frequency domain filter and adapting a cut-off frequency when the noise components are decorrelated from the useful signal in the frequency domain. These methods are time consuming and depend on the cut-off frequency and the filter function behaviour. Furthermore, they may produce artificial frequencies in the processed image.

Wavelet domain:-Filtering operations of the wavelet domain can be subdivided into linear and nonlinear methods.

Linear Filters:-Linear filters like Wiener filter in the wavelet domain yield optimal results when the signal corruption can be modelled as a Gaussian process and the accuracy criterion is the mean square error (MSE). However, designing a filter based on the assumption of this filters are frequently results in a filtered image that is more visually displeasing than the original noisy signal, even though the filtering operation successfully reduces the MSE. In a wavelet-domain spatially adaptive FIR Wiener filtering for image denoising is proposed where wiener filtering is performed only within each scale and intrascale filtering is not allowed.

Non-Linear Threshold Filtering:-The one of the most investigated domain in denoising using Wavelet Transform is the non-linear coefficient thresholding based methods. This procedure exploits sparsity property of the wavelet transform and the fact that the Wavelet Transform maps white noise in the signal domain to white noise in the transform domain.

Non-orthogonal Wavelet Transforms:-NOWT is also used for Undecimated Wavelet Transform (UDWT) has also been used for decomposing the signal to provide visually better solution. Since UDWT is shift invariant it avoids visual artifacts such as pseudo-Gibbs phenomenon.

Wavelet Coefficient Model:-Wavelet coefficient model approach focuses on exploiting the multiresolution properties of Wavelet Transform. It identifies close correlation of signal at different resolutions by observing the signal across multiple resolutions. It produces excellent output but is computationally much more complex and expensive. The modeling of the wavelet coefficients can either be deterministic or statistical. Although WT has demonstrated its efficiency in de-noising it uses fixed wavelet basis (with dilation and translation) to represent the image. For natural images however there is a rich amount of different local structural patterns which cannot be well represented by using only one fixed wavelet basis. So WT based method can introduce many visual artifacts in the de-noising output. To overcome this problem PCA based de-noising schema is used.

PCA:-Principal component - a linear combination of the original variables (1^{st} principal component explains most of the variation on the data, 2^{nd} PC explains most of the rest of the variance and so on) Eigenvectors - the coefficients of the original variables used to construct factors. Eigen value - a corresponding scalar value for each eigenvector of a linear transformation. There are three basic assumptions behind PCA that need to be considered when calculating and interpreting principal components:

Linearity - Linearity frames the problem as a change of basis. Several areas of research have explored how extending these notions to nonlinear regimes.

Large variances have important structure - This assumption also encompasses the belief that the data has a high SNR. Hence, principal components with larger associated variances represent interesting structure, while those with lower variances represent noise. Note that this is a strong, and sometimes, incorrect assumption.

The principal components are orthogonal - This assumption provides an intuitive simplification that makes PCA soluble with linear algebra decomposition techniques.

II. LITERATURE SURVEY

In this section, we describe the related work on image de-noising:

In 2013 **Kanika Gupta, S.K Gupta [**1]describe that Image denoising is the fundamental problem in Image processing. Wavelet gives the excellent performance in field of image de-noising because of sparsity and multi-resolution structure. With the popularity of Wavelet Transform for the last two decades, several algorithms have been developed in wavelet domain. The focus was shifted to Wavelet domain from spatial and Fourier domain.

In 2014 **Manoj Gabhel1, et al**[2] Working in Wavelet domain is preferred because the Discrete Wavelet Transform (DWT) make the signal energy concentrate in a small number of coefficients, hence, the DWT of the noisy image consists of a small number of coefficients having high Signal to Noise Ratio (SNR) while relatively large number of coefficients is having low SNR. After removing the coefficients with low SNR

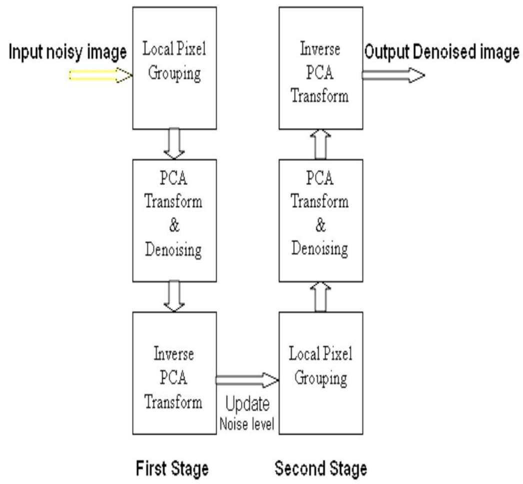

Figure 1. Two stage Image De noising technique

(i.e., noisy coefficients) the image is reconstructed by using inverse DWT. As a result, noise is removed or filtered from the observations . A major advantage of Wavelet methods is that it provides time and frequency localization simultaneously. Moreover, wavelet methods characterize such signals much more efficiently than either the original domain or transforms with global basis elements such as the Fourier transform.

In 2012 **Y. Murali et al** [3]PCA is accomplished by a linear transformation of variables that corresponds to a rotation and translation of the original coordinate system. PCA is used to find out principal components in accordance with maximum variance of a data matrix. Based on the principle components a new technique, based on maximization of SNR was also proposed.

In 2009 **Devesh Bhalla et al**[4] tells about the new noise removal technique. In this paper, an algorithm is proposed to detect the corrupted pixel in a digital image and then remove the noise from that image. Firstly, the colored image is broken up into its three basic colours red, green and blue then each of these images is passed through the proposed algorithmic filter then noise is detected in all these images and then corrected. Median of all the pixel value is taken by giving weight to the centre pixel. There is also a minimum intensity level is decided through which the comparison of all median values is done to make a final knee intensity value.

In 2015 **Yali liu**[5] describe new noise removal approach. In this paper it tells that Threshold denoising is based on the comparison of transform domain coefficients and threshold value, and processed coefficient should be transformed to reconstruct the denoising image. Concrete steps of wavelet threshold denoising method are shown as the following:

Step 1: wavelet decomposition of the image: Determine the wavelet function and
Decomposition levels N, and decompose the image with N layer wavelet.
Step 2: Threshold selection: select the threshold for each wavelet coefficients of each
layer, and judge the threshold of detail coefficients.
Step 3: Image reconstruction: coefficient with threshold processed will be used to
Reconstruct the image by inverse wavelet transform.

In **2007 Kostadin Dabov**[6] describe image denoising technique. In this paper, we propose a novel image denoising strategy based on an enhanced sparse representation in transform-domain. The enhancement of the sparsity is achieved by *grouping* similar 2-D fragments of the image into 3-D data arrays which we call "groups." *Collaborative filtering* is a special procedure developed to deal with these 3-D groups. It includes three successive steps: 3-D transformation of a group, shrinkage of transform spectrum, and inverse 3-D transformation. Thus, we obtain the 3-D estimate of the group which consists of an array of jointly filtered 2-D fragments. Due to the similarity between the grouped fragments, the transform can achieve a highly sparse representation of the true signal so that the noise can be well
separated by shrinkage. In this way, the collaborative filtering reveals even the finest details shared by grouped fragments and at the same time it preserves the essential unique features of each individual fragment.

In 2015 **Rinci Shrivastav et al**[7] tells that Peak signal-to-noise ratio (PSNR) is a ratio between the maximum power of a signal and the power of distorting noise that affects the quality of its representation of the signal or the image. The block of PSNR computes the peak signal-to-noise ratio between two images. The unit of PSNR is in decibels. This ratio is the measurement of noisy images in comparison to the denoised images. The higher the PSNR, the better the quality of the final image or the denoised image achieved. The Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR) are the two error metrics used to compare the quality of noisy in comparison to the denoised image.

In **Rafael C. Gonzalez " digital image processing"**[8]Images based on radiation from the EM spectrum are the most familiar, especially images in the X-ray and visual bands of the spectrum. Electromagnetic waves can be conceptualized as propagating sinusoidal waves of varying wavelengths, or they can be thought of as a stream of mass less particles, each travelling in a wavelike pattern and moving at the speed of light. Each mass less particle contains a certain amount (or bundle) of energy. Each bundle of energy is called a photon.

III. CONCLUSIONS

Performance of denoising algorithms is measured using quantitative performance measures such as peak signal-to-noise ratio (PSNR), signal-to-noise ratio (SNR) as well as in terms of visual quality of the images. Many of the current techniques assume the noise model to be Gaussian. In reality, this assumption may not always hold true due to the varied nature and sources of noise. An ideal denoising procedure requires *a priori* knowledge of the noise, whereas a practical procedure may not have the required information about the variance of the noise or the noise model. Thus, most of the algorithms assume known variance of the noise and the noise model to compare the performance with different algorithms. Gaussian Noise with different variance values is added in the natural images to test the performance of the algorithm. The better preservation of image local structures, a pixel and its nearest neighbors are modeled as a vector variable, whose training samples are selected from the local window by using block matching based LPG. Such an LPG procedure guarantees that only the sample blocks with similar contents are used in the local statistics calculation for PCA transform estimation, so that the image local features can be well preserved after coefficient shrinkage in the PCA domain to remove the noise.

REFERENCES

[1] K. Gupta and S. K. Gupta, "Image Denoising Techniques- A Review paper," no. 4, pp. 6–9, 2013.

[2] M. Gabhel and A. Hiradhar, "Comparative Analysis of Various Image Denoising Techniques : A Review Paper," vol. 3, no. 7, pp. 1877–1881, 2014.

[3] Y. Murali Mohan Babu, "PCA based image denoising," Signal Image Process. An Int. J., vol. 3, no. 2, pp. 236–244, 2012.

[4] D. Bhalla and A. Goen, "Noise Detection Chromatic Median Filter for Denoising Digital Color Image," vol. 5, no. 12, pp. 618–624, 2015.

[5] Y. Liu, "Image Denoising Method based on Threshold , Wavelet Transform and Genetic Algorithm," vol. 8, no. 2, pp. 29–40, 2015.

[6] K. Dabov, A. Foi, and V. Katkovnik, "Image denoising by sparse 3D transformation-domain collaborative filtering," IEEE Trans. Image Process., vol. 16, no. 8, pp. 1–16, 2007.

[7] R. Shrivastava, R. Mohan, and A. Shukla, "Wavelet based Linear Gaussian Image Denoising Methods," no. 2, 2015.

[8] R. Gonzalez and R. Woods, Digital image processing. 2002