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A review of Image noises and Comparative analysis of image Denoising techniques

KEYWORDS: Denoising, Smart-camera, PSNR, SVD, ICA, PCA, Filtering Methods.

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ABSTRACT Digital images are noisy due to ecological disturbances and it is degrade the quality of images. Data sets collected by image sensors are generally infected by noise and it is due to imperfect instruments. There is a wide variety of noise types while we focus on the most important types of noises and denoising techniques been developed to reduce noise from corrupted images to enhance image quality is discussed in this paper. This paper presents a review of some significant work in the area of image denoising and advantages of digital smart cameras verses film cameras. The effective noise removal techniques are discussed for various types of images and from the introduction we can conclude that the SVD technique is the best technique for image denoising in terms of image quality improvement as per lots of literature review.

I.INTRODUCTION

IMAGE denoising is still remains a challenge for researchers because noise removal introduces artifacts and causes blurring of the images. This paper describes different methodologies for noise reduction in terms of PSNR comparison giving an insight as to which technique should be used to find the most reliable estimate of the original image data given its degraded version. Noise modeling in images is greatly affected by capturing instruments, data transmission media and discrete sources of radiation such cameras. Depending on the type of the noise, the degradation of the image will vary. According to the percentage of image quality degradation, the noise removal techniques must be chosen. The wavelet transform, curve let transform and wave atom transform are the efficient transforms for image denoising algorithms.

A. Characteristics and Advantages of Smart Cameras [18-21]

Compared to normal cameras, such as CCTV cameras, web and IP (Internet Protocol) cameras, industrial video cameras, and other general-purpose cameras, smart cameras may look quite similar from the outside, but they have some distinct characteristics which make them smart and useful.

The defining component in a smart camera is its ASIP block, as shown in Fig. 1.1.

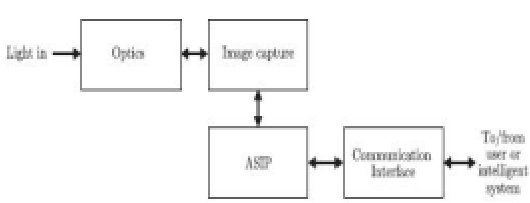

Fig.1.1: Functional block diagram of a smart Camera

Currently, there are five commonly used high bandwidth camera interface standards. Table 1.1 shows the comparison of these standards.

Table 1.1: Specification of Camera Interfaces

Criteria	Connection Type	BW	Distance	Wireless Support
GigE Vision	Point to Point	<1000 Mpbs	< 100m	Yes
Fire Wire 800	Peer to Peer	< 800 Mpbs	< 4.5m	No
USB 2.0	Master-Slave	<480M pbs	< 5m	No
Camera Link	Point to Point	2,38047 607, 140 Mpbs	< 10m	No

B. Noise Model and Characteristic [3-9, 21]

Different algorithms are used depending on the noise model. Most of the natural images are assumed to have additive random noise which is modeled as a Gaussian. The scope of the paper is to focus on noise removal techniques for natural images. Interference can be added to an image during transmission. We can consider a noisy image to be modeled as follows: $g(x, y) = f(x, y) + \eta(x, y)$ Where $f(x, y)$ is the original image pixel, $\eta(x, y)$ is the noise term and $g(x, y)$ is the resulting noisy pixel.

Fig.1.2 Noise Model

Gaussian noise - The standard model of amplifier noise is additive, Gaussian, independent at each pixel and

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independent of the signal intensity.

Salt-and-pepper noise - Impulsive noise is sometimes called salt & pepper noise or spike noise. An image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions.

Shot noise - The dominant noise in the lighter parts of an image from an image sensor is typically that caused by statistical quantum fluctuations, that is, variation in the number of photons sensed at a given exposure level; this noise is known as photon shot noise.

II.EVOLUTION OF IMAGE DENOISING RESEARCH [1-5, 7-17]

The image denoising schemes such as smoothing filters and frequency domain denoising methods, wavelet based methods, curve let based methods, ridge let based methods, sparse representation method, shape-adaptive transform, bilateral filtering, non-local mean based methods, non local collaborative filtering, Bi-Shrink, SURE-LET, Block-Shrink, Neigh-Shrink SURE, LPGPCA, NLM-SAP and non-linear fourth order partial differential equation are some of the major methods used for AWGN noise removal. In order to overcome the drawback of wavelet transform based denoising algorithm, spatially adaptive Principal Component Analysis (PCA) based denoising scheme is proposed. Sparse redundant representation and K-SVD based denoising algorithms are proposed for image denoising.

III. CLASSIFICATION OF DENOISING TECHNIQUES [6-9, 10-16]

As shown in Fig. 3.1, there are two basic approaches to image denoising, spatial filtering methods and transform domain filtering methods.
A. Spatial Filtering

A traditional way to remove noise from image data is to employ spatial filters. Spatial filters can be further classified into non-linear and linear filters.
Non-Linear Filters - With non-linear filters, the noise is removed without any attempts to explicitly identify it.
Linear Filters - A mean filter is the optimal linear filter for Gaussian noise in the sense of mean square error.
B. Transform Domain Filtering

The transform domain 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.
Bayes-Shrink - The main objective of this algorithm is to minimize the Bayesian risk and hence its name, Bayes-Shrink. Its denoising performance is poor in high density additive white Gaussian noise.
Spatial-Frequency Filtering - Spatial-frequency filtering refers use of low pass filters using Fast Fourier Transform (FFT).
Non-Linear Threshold Filtering - The most investigated domain in denoising using Wavelet Transform is the non-linear coefficient thresholding based methods.

C. Wavelet Denoising

This method produces excellent output but is computationally much more complex and expensive. This approach focuses on some more interesting and appealing properties of the Wavelet Transform such as Multi scale correlation between the wavelet coefficients, local correlation between neighborhood coefficients etc. The term "wavelets" is used to refer to a set of orthonormal basis functions generated by dilation and translation of scaling function Φ and a mother wavelet Ψ.

D. Data-Adaptive Transforms

ICA - Independent Component Analysis has gained wide spread attention in recent research. The ICA method was successfully implemented in denoising Non-Gaussian data.
PCA - Principal Component Analysis is an exploratory tool designed by Karl Pearson in 1901 to identify unknown trends in a multidimensional data set X. However, today we know that implementing PCA is the equivalent of applying Singular Value Decomposition (SVD) on the covariance matrix of a data set.

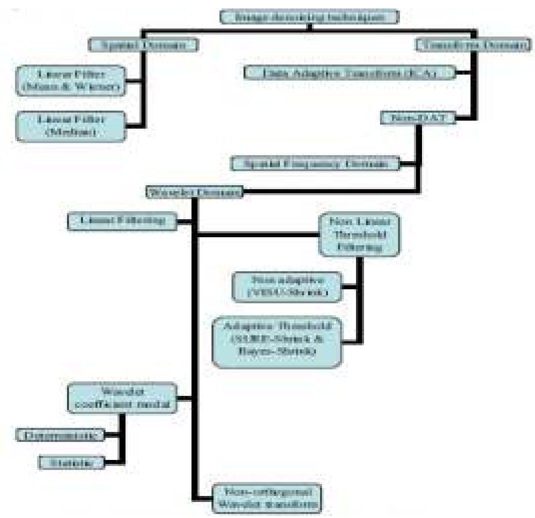

Fig.3.1 Classification of denoising technique

Adaptive PCA - It is a second order statistical approach, which has been used to extract the features of data set or perform data reduction (compression). Specially, when data set is, redundant and overwhelming large, PCA is very effective linear technique as a preprocessing step to extract data features and to cluster data for classification.

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IV. REVIEW OF SVD [1, 5-17]

MOD and MAP methods are involved in K SVD. MOD (method of direction) is similar to k-means clustering. N observations are partitioned to k clusters and each observation belongs to each cluster by its nearest mean value. MAP method is used for increasing the closeness to single value detection. It combines with MOD efficiency and recovers dictionary. PSNR is high for compression. In the theory part some important definitions related to the SVD and compare the SVD of a matrix A with the Eigen-value decomposition of ATA, which results in a degree of uniqueness for the SVD. The application part of how the SVD is used to calculate linear least squares, and how to compress data using reduced rank approximations.

Let A be an m by n matrix. Then the SVD of A is UΣVT where U is m by m, V is n by n, and Σ is an m by n diagonal matrix where the diagonal entries Σii = Σi are nonnegative, and are arranged in non-increasing order. The positive diagonal entries are called the singular values of A. The columns of U are called the left singular vectors for A and the columns of V are called the right singular values for A. The SVD and the eigen-value decomposition are similar and closely related. The SVD of A can be used to determine the Eigen-value decomposition of ATA. In particular, the right singular vectors of A are the eigenvectors of ATA, and the singular values of A are equal to the square roots of the eigenvalues

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of ATA. It also turns out that the left singular vectors of A are the eigenvectors of AAT. This shows that if the SVD of A is A = UΣVT, U and V are uniquely determined except for orthogonal basis transformations in the Eigen-spaces of ATA and AAT.

V. RESULT AND DISCUSSION

Performance of denoising algorithms is measured using quantitative performance measures such as peak signal-to-noise ratio (PSNR), structural similarity index (SSIM) as well as in terms of visual quality of the images. Many of the current techniques assume the noise model to be Gaussian. 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.

Table 5.1 and Fig. 5.1 shows Comparison of different denoising techniques in terms of image assessment parameters and employed technique in reference 8 has been better PSNR values compared to other techniques. In reference 8 authors have been discussed MOD and MAP methods and MOD (method of direction) is similar to k-means clustering. N observations are partitioned to k clusters and each observation belongs to each cluster by its nearest mean value.

A literature survey for different image denoising techniques was done. Proposed method can provide better results in terms of image quality and similarity measures. Future scope is to calculate the amount of noise added to the pixel, removal of noise and evaluating the signal to noise ratio.

Table 5.1: PSNR Comparison of denoising techniques

Parameters	Technique employed	Efficiency Measure
Reference 3 & 4	Three types of noises are removed by applying five algorithms. Modified SMF is useful for different noise removal.	PSNR is high in MSMF filter; MSE is low in median filter.
Reference 4 &5	Different OCT images are extracted and tested with various filters for checking visual effectiveness	PSNR is low for FBT compared to WGE.
Reference 7	Noisy image is sent to local pixel grouping and by PCA transform and inverse PCA denoised output obtained, BM3D algorithm Developed.	PSNR value is high, SSIM value is high compared to reference 3, 4 &5.
Reference 8	MOD works similar clustering and MAP method increases closeness to K-SVD detection.	PSNR value is high reference 7.
Reference 4 &11	Curvelet with ridgelet used to provide efficient work on digital inputs and denoised output. Curves are recovered sharply.	PSNR value is better in multi-scale entropy with some few noises but low compared to reference 7&8.

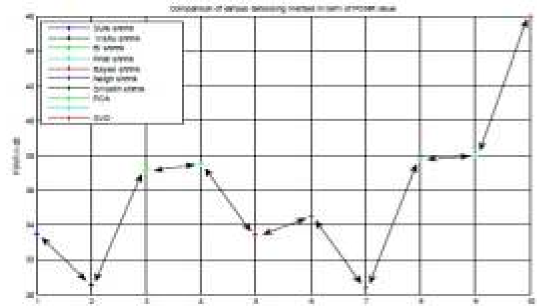

Fig. 5.1: Comparison of image denoising method using graph

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REFERENCE

[1] D Kalman, A Singularly Valuable Decomposition: The SVD of a Matrix, The American University, February 13, 2002. | [2] R N Patel, Jignesh Patoliya, S D Joshi, "Uniform Discrete Curvelet Transform for Image Denoising", in International Conference E3C-2010 J D College of Engg, Nagpur, 9- Jan, 2010, ISBN 978-81-8487-160-9. | [3] Ratansing Patel, S.D.Joshi, Dharmendra Chauhan,Jignesh Patoliya, "Performance comparison of Mean, Edge Number of Looks and Peak Signal to Noise Ratio for Curvelet Based Image Denoising", in IJECE International Research Publication Delhi IJECE/Volume 3, Number 3b (2010), pp. 331-340, ISSN 0974-2166. | [4] R.N.Patel, J.V. Dave, Hardik Patel, Hitesh Patel,"Denoising Performance of Lena Image between Filtering Techniques, Wavelet and Curvelet Transforms at different noise level" in IJAET New Delhi, IJAET/ Volume II/ Issue II/ April-June'2011/ 276-283, E-ISSN 0976-3945. | [5] Martin Vetterli, Jelena Kovaˇcevi, 2007. Wavelets and Subband Coding, Prentice Hall, Englewood Cliffs, NJ. | [6] Shyam Lal, Mahesh Chandra, 2012. Image Denoising of Wavelet based Compressed Images Corrupted by Additive White Gaussian Noise, Research Journal of ASET 4(17): 3108-3118, 2012. | [7] Marc Lebrun, 2012, An analysis and Implementation of the BM3D Image Denoising Method. Image Processing on Line, 2012–6–26. | [8] Arthur Leclaire, Marc Lebrun, An implementation and detailed analysis Of the K-SVD image denoising algorithm.Image Processing On Line, 2012. | [9] H. Guo, J. E. Odegard, M. Lang, R. A. Gopinath, I. W. Selesnick, and C. S. Burrus, "Wavelet based speckle reduction with application to SAR based ATD/R," First Int'l Conf. on Image Processing, vol. 1, pp. 75-79, Nov. 1994. | [10] Robert D. Nowak, "Wavelet Based Rician Noise Removal",IEEE Transactions on Image Processing, vol. 8, no. 10, pp.1408, October 1999. | [11] D. L. Donoho, "De-noising by soft-thresholding",IEEE Trans. Information Theory, vol.41, no.3, pp.613-627,May1995. http://wwwstat.tanford.edu/~donoho/Reports/1992 /denoisereleas e3.ps.Z. | [12] Imola K. Fodor, Chandrika Kamath, "Denoising through wavlet shrinkage An empirical study", Center for applied science computing Lawrence Livermore National Laboratory, July 27, 2001. | [13] Ajit Rajwade, Student Member, IEEE, Anand Rangarajan, Member, IEEE, and Arunava Banerjee, Member, IEEE, Image Denoising Using the Higher Order Singular Value Decomposition, IEEE Transactions on pattern analysis and machine Intelligence, vol. 35, No.4, April 2013. | [14] Analysis K-SVD: A Dictionary-Learning Algorithm for the Analysis Sparse Model by Ron Rubinstein, Member IEEE, Tomer Peleg, Student Member, IEEE and Michael Elad, Fellow, IEEE. | [15] A survey Paper on Image Denoising Techniques by Shruti Bhargava, Dr. Ajay Somkuwar, Mini Gupta, International Journal of Electronics Communication and Computer Engineering Volume 3, Issue 3, ISSN 2249 –071X. | [16] A Survey on Image Denoising Algorithms (IDA),Prof.R.Gayathri1, Dr.R.S.Sabeenian2, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 1, Issue 5, November 2012. | [17] A Review of a Singularly Valuable Decomposition: The SVD of a Matrix, Reed Tillotson, June 6, 2013. | [18] Smart Camera Mote With High Performance Vision System, Richard Kleihorst, Ben Schueler, Alexander Danilin, Marc Heijligers Philips Research Laboratories, WAY4.1, Prof. Holstlaan 4, NL5656AA Eindhoven, The Netherlands. | [19] A.N.Belbachir (ed.), Smart Cameras, DOI 10.1007/978-1-4419-0953-4 2, Springer Science+ Business Media, LLC 2010. | [20] Smart Cameras: A Review Yu Shi*, Serge Lichman Interfaces, Machines And Graphical Environments (IMAGEN) NationalInformation and Communications Technolog Australia(NICTA) Australian Technology Park,Bay 15 Locomotive Workshop Eveleigh, NSW 1430, Australia | [21] Wickpidia,. Digital Image processing, Availableathttp://en.wikipedia.org/wiki/Digital_image_processing