International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

# A Comparative Approach On Noise Estimation and Removal Through PCA, Median and Wavelet Filter

**Jagdish Patel[1], Rekhansh Rao[2]**

[1]M.Tech. Scholar, Computer Science and Engineering, Rungta College of Engg & Technology, Bhilai (Chhattisgarh) India

[2]Assistant Professor, Department of Computer Science and Engineering, Rungta collage of engineering & technology. Bhilai (Chhattisgarh), India

**Abstract:** ***The use of the paper is organized as follows section type of noise can be introduced in an images noise estimation and noise removal on various digital images. Before analysis or using image to ensure the quality of image in image processing noise estimation and removal are very important step. Due to low contrast and high noise in an image most algorithms have not yet attained a desirable level of applicability. In This paper deals with image de-noising by using the PCA (principal component analysis), Median filter and wavelet analysis. The comparative analysis will then be performed based on the three parameters Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE) and Edge Preserving Index (EPI).***

**Keywords:** Noise; Denoising; Transform; Wavelets; MSE

## 1. Introduction

Image restoration (denoising) is an active and important step in image analysis, with applications in recognition [1], segmentation [2] and tracking [3]. In reality, the image will inevitably be mixed with a certain amount of noise. The noise will deteriorate the quality of the images. So it is necessary to deal with image noise in order to deal with a higher level processing. The purpose of image denoising is as much as possible to maintain the main features of the image and remove as much as possible noise from images. Recently very promising image restoration results are reported using wavelet transform [4], bilateral filtering [5], nonlocal averaging [6], sparsity [7] and subspace [8] based methods. According to actual image characteristic, noise statistical property and frequency spectrum distribution rule, people have developed any methods of eliminating noises, which approximately are divided into space and transformation fields The space field is data operation carried on the original image, and processes the image grey value, like neighborhood average method, wiener filter, center value filter and so on. The transformation field is management in the transformation field of pictures, and the coefficients after change.for gray-level. Generally they are classifiable into segment-based are processed. Many algorithms [2][9][10][11] have been proposed for gray level. By and large they are classifiable into fragment based and filter-based approaches, or some combination of them. Principal component analysis is a statistical procedure that uses an orthogonal property to transform to convert a set of observations of possibly correlated variables into a set of values of uncorrelated variables. The denoising phenomenon goal is to remove the noise while retaining the maximum possible the important signal or image features. To achieve a good performance in this admiration, a denoising calculation needs to adjust to images discontinuities. Generally the quality of image can be measured by the peak signal-to-noise ratio (PSNR). Many algorithm are based on the PCA based denoising like CFA- PCA, two stage denoising PCA through LPG and Bayesian PCA [8] and so on. By using the wavelet transform a novel image enhancement approach is proposed. First, a image was decomposed with wavelet transform secondly, noise in the frequency field was reduced by the delicate edge system. Thirdly, high-recurrence coefficients were enhanced by different weight values in different sub-images rest of the paper is organized as follows. In section 2 we gave a brief overview of the different image noise type, section 3 contains the technique for remove noise from image, in section 4,5 image denoise with median filter, PCA and wavelet transform, in section 6 experimental results are discussed, finally we summarize the conclusion in section 7.

## 2. Image Noise Type

### 2.1 Gaussian Noise-

The standard model of amplifier noise is Gaussian, additive, free at each pixel and free of the signal intensity, caused mostly by thermal noise, including that which comes from the rearrange noise of capacitors. In color cameras where additional amplification is used there can be more noise in the channel. Amplifier noise is a most important component of the "read noise" of an image sensor [12].

### 2.2 Salt-and-Pepper Noise

Fat-tail distributed or "impulsive" noise is at times called spike noise or salt-and-pepper noise. An image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions. This type of noise can be caused by ADC errors, bit errors in transmission, etc. lifeless pixels in an LCD screen produce a like, but non-random, display. This can be eliminated in huge part by using dark/bright pixels.

### 2.3 Poisson Noise

The dominant noise in the lighter parts of an image from an image sensor is characteristically that caused by statistical quantum changes, i.e., variety in the measure of photons sensed at a given disclosure level; this noise is called as photon shot noise. Short noise have a root-mean-square value relative to the square root of the image intensity, and the noises at dissimilar pixels are independent of one more.

Shot noise follows a Poisson distribution, which is usually not very unlike from Gaussian. Notwithstanding photon shot clamor, there can be current in the image sensor; this noise is sometimes known as "dark-current shot noise" or "dark shot noise".

### 2.4 Speckle Noise

Speckle noise is a multiplicative additional shot noise from the dark spillage commotion. This sort of clamor happens in pretty much all coherent imaging systems [13]. The source of this noise is attributed to random interference between the coherent returns. Speckle noise has the characteristic of multiplicative noise and it obey distribution given as

$$f(g) = \{ \frac{g^{\alpha-1}}{(\alpha-1)!\,\alpha^{\alpha}} \} e^{-\frac{g}{\alpha}} \quad ..(1)$$

Where variance is a 2α and g is the gray level.

## 3. Technique for Removal of Noise From Image

### 3.1 Noise Estimation Through PCA

Conventional noise level estimation strategies can be categorized into three main classes:-

#### 3.1.1 Texture based noise estimation

Weak texture patch based noise Xinholui [6] estimation through principal component analysis. They proposed algorithm use select weak textured patches from a single noisy image based on the gradients of the patches and their statistics.

#### 3.1.2 Block Based noise estimation

A new noise level estimation Pyatykh [4] present a method. It is based on principal component analysis (PCA) of image blocks. The advantages of this method is

1) Highly efficient.
2) It is more useful for estimate noise for texture area, Even if the area is not homogeneous.
3) It is provide better accuracy than the other algorithms.

It does not require the existence of homogeneous areas in the input image and also can be applied to textures. The results shows that only stochastic textures, whose correlation properties are very close to those of white noise, cannot be successfully processed.

### 3.2 Noise Removal through PCA

Traditional denoising methods can be generalized into two main groups: spatial domain filtering and transform domain filtering. By reference to image operators that change the gray value at any pixel (x, y) depending on the pixel values in a square neighborhood centered at (x, y) using a fixed integer matrix of the similar size. The integer matrix is called a filter, kernel, mask or a window. The procedure consists of moving the filter mask from pixel to pixel in an image. At all pixel (x, y), the response is given by a summation of products of the filter coefficients and the corresponding image pixels in the area spanned by the filter mask.

#### 3.2.1 Patch Based PCA for image denoising

The algorithms consider three methods: local PCA, hierarchical PCA and global PCA. It consists of the following two steps:

a) By performing a Principal Component Analysis (PCA), an orthogonal basis from the noisy image.
b) By zeroing all the small coefficients in the representation of the noisy patch in the learned basis. Obtaining the denoised patch.

Patch based Global PCA (PGPCA): By creating an orthogonal basis adapted to the target image using a PCA on the whole collection of patches extracted from the image.

Patch based Hierarchical PCA (PHPCA): With the help of quad trees with iterative partitions, i.e. we recursively divide the image into four rectangles and proceed to the PCA to the level k of partitioning. At each step a few (usually one) axes are added to the bases and the remaining patches are projected onto the orthogonal supplement of the current orthogonal sub-basis.

Patch based Local PCA (PLPCA): Apply dynamic localization to build the axes. It relies on a sliding window of size WS * WS in which the patches are selected to proceed to a local PCA.

#### 3.2.2 Two Stage Image Denoising By Principal ComponentAnalysis

An efficient image denoising scheme Zhang [3] by using principal component analysis (PCA) with local pixel grouping (LPG). The algorithm divides in to two stages. The first stage evaluates an initial estimation of the image by removing most of the noise and the second stage will further refine the output of the first stage. The two stages have the same procedures except for the parameter of noise level. Number of PC is equal or less than the original values. Then passed to inverse PCA transform and denoised output is taken as a result

### 3.3 PCA-Based Spatially Adaptive Denoising of Images

Principal component analysis Zhang [5] based denoising algorithm which works on directly on the color filleting array (CFA) images. This algorithm can effectively suppress noise while preserving color edges and details. The technique of principle component analysis (PCA) is employed to analyze the local structure of each CFA variable block, which contains color components from different channels. The proposed spatially adaptive PCA denoising scheme works directly on the CFA image and it can effectively exploit the spatial and spectral correlation simultaneously.

## 4. Image Denoising

Image denoising refers to the recovery of a digital image that has been impure by the noise. In case of image Denoising methods, the traits of the degrading process and the noises are assumed to be known beforehand.

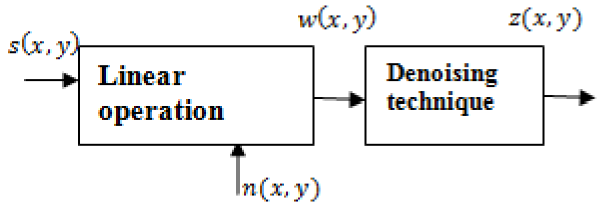


**Figure 1:** Denoising concept

The image s(x, y) is blurred by a linear operation [20]and noise n(x, y) is brought to form the debased picture w(x, y). This is convolved with the rebuilding procedure g(x, y) to produce the restored image z(x, y). The "Linear operation" shown in Fig.1 is the addition or multiplication of the noise n(x, y) to the signal s(x, y)

**Median Filter**:

Median filter are statistical non- linear filters that are often described in the spatial domain. A median filter smoothness the image by utilizing the median of the neighborhood. Median filter performs the following task to find each pixel value in the processed image. All pixels in the neighborhood of the pixel in the original image which are identified by the mask are sorted in the ascending or descending order. The median filter of the sorted value is computed and is chosen as the pixel value for the processed image. It follows the moving window principle and uses 3×3, 5×5 or 7×7 window. The median of window is calculated and the middle pixel value of the window is replaced by that value.

## 5. Wavelet Transform

Wavelet mean 'small wave', so wavelet analysis is about analyzing signal with small duration-finite energy functions. The wavelet transform is defined as follows

$$w_k^j = \int f(x)\varphi\left(\frac{x}{2j} - k\right)dx \quad \dots (5.1)$$

Where is the transforming function and is called the mother wavelet, f(x) is the original signal. j and k are scale and translation parameters, respectively.

When considering the analysis of digital images, we may use the two-dimensional dyadic discrete-time wavelet transform 2D-DTWT, which uses mother wavelet function φ to decompose a digital image into a multilevel set of approximation and detail (*i.e.* vertical, horizontal, and diagonal) wavelet coefficient $c_A^l, c_{DV}^l, c_{DH}^l$, and $c_{DD}^l$ where l = 1, 2,..., L is the level of decomposition. At each level of decomposition, the approximation wavelet coefficients are decomposed into a new set of approximation and detail coefficients. This can be represented as a frequency sub-band division. The theory of wavelet transform is explained in many publications, a more detailed description of the wavelet transform and its properties can be found, for example, in [14].

### 5.1 Thresholding Techniques

It comprises the reduction or complete removal of selected wavelet coefficients in order to separate out the noise within the signal. The thresholding method, used in the wavelet based de-noising technique, distinguishes between insignificant coefficients, which are likely due to the noise of magnetic resonance device, and significant coefficients, which consist of important signal components [15]. It is assumed that wavelet coefficients with a value lower than a particular threshold value T correspond to noisy samples and they can be therefore cancelled, which leads to noise reduction in the image domain. Two basic thresholding techniques are hard and soft thresholding. When the hard thresholding technique is used, then the wavelet coefficients that are lower than threshold value T are cancelled and the remaining coefficients are unaffected

$$\hat{c}(i) = \begin{cases} c(i) & |c(i)| < T \\ 0 & |c(i)| < T \end{cases} \quad \dots (5.2)$$

The soft thresholding technique cancels the wavelet coefficients that are lower than threshold T, but it also tries to isolate signal from noise in the remaining coefficients by subtracting the threshold value from them

$$\hat{c}(i) = \begin{cases} sign[c(i)].[|c(i)| - T], & |c(i)| \geq T \\ 0, & |c(i)| < T \end{cases} \quad ..(5.3)$$

Generally, soft thresholding tends to have a bigger bias due to the threshold of large coefficients, while hard thresholding tends to be of bigger variance and unstable due to discontinuities of the threshold function [16]. But other thresholding methods can be used to obtain a compromise between these two drawbacks through the inverse wavelet transform the enhanced image was generated.

## 6. Results

The table below shows the comparative analysis between Noisy image, Wavelet and PCA method as discussed below. On concluding node the PCA is better than other technique to remove noise from image i.e. denoised image [19].

**Table 1:** Experimental Result for Removal of Speckle Noise

| Filters/ Noise variance | Wavelet | PCA | Median |
|---|---|---|---|
| 3% | 44.7643 | 34.15 | 33.3768 |
| 5% | 38.6974 | 30.01 | 28.4543 |
| 7% | 37.6806 | 28.13 | 27.5214 |
| 9% | 40.046 | 26.99 | 25.2348 |

**Table 2:** Experimental Result for Removal of Poisson Noise

| Filters/ Noise variance | Wavelet | PCA | Median |
|---|---|---|---|
| 3% | 39.2642 | 34.15 | 33.3358 |
| 5% | 36.268 | 30.01 | 28.4613 |
| 7% | 35.2619 | 28.13 | 27.5214 |
| 9% | 37.1204 | 26.99 | 25.2348 |

**Table 3:** Experimental Result for Salt and Pepper Noise

| Filters/Noise variance | Wavelet | PCA | Median |
|---|---|---|---|
| 3% | 36.5417 | 40.21 | 39.6668 |
| 5% | 34.4159 | 39.11 | 37.5443 |
| 7% | 33.34 | 35.44 | 34.1299 |
| 9% | 35.256 | 34.62 | 33.2638 |

**Table 4:** Experimental Result for Different Noise Removal using PCA and Wavelet

| Noise | Noisy Image | Wavelet | PCA |
|---|---|---|---|
| Random | 31.0019 | 31.0178 | 63.7236 |
| Salt & Pepper(d=0.01) | 50.7831 | 42.8442 | 48.1779 |
| Speckle (v=0.01) | 38.3986 | 39.9936 | 61.7548 |
| Poisson | 37.6376 | 39.209 | 53.2899 |

## 7. Discussion

The comparative analysis will then be performing based on the three parameters Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR) and most importantly Edge Preserving Index (EPI). MSE and PSNR are the most important parameters often used for evaluation of image denoising processes and the EPI is very useful to evaluate preservation of edges during image denoising, higher value of EPI indicating higher edge preservation [17]. Principal component analysis is used for both noise estimation and noise removal. Principal component analysis is used with different methods like LPG and CFA for denoising. This paper focused on the use of principal component analysis and wavelet transform for noise estimation and noise removal though different types of algorithms. It is expected that the future research will focus on building robust statistical models of Principal component analysis based on their feature.

## References


[1] S. I. Olsen, "Estimation of Noise in Images: An Evaluation, "Graphical Models and Image Process. vol. 55, pp. 319-323, July1993.

[2] Tai Shen-chuan and Yang Shih-ming, "A fast method for image noise estimation using laplacian operator and adaptive edge detection," 3rd International Symposium on Communications, Control and Signal Processing, pp. 1077–1081, March 2008.

[3] Lei Zhang , Weisheng Dong, David Zhang, GuangmingShib, "Twostage image denoising by principal component analysis with local pixel grouping", Science Direct, Pattern Recognition , Vol. 43 , 1531–1549, 2010.

[4] Pyatykh, Stanislav, Zheng, Lei and Hesser, Jürgen, "Fast noise variance estimation by principal component analysis", *Proc. SPIE*8655, Image Processing: Algorithms and Systems XI, vol. 8655, February 19, 2013; doi:10.1117/12.2000276.

[5] Lei Zhang, RastislavLukac, Xiaolin Wu and David Zhang,"PCABased Spatially Adaptive Denoising of CFA images for Single- Sensor Digital Cameras" IEEE Transactions on Image Procession, VOL. 18, NO. 4, APRIL 2009.

[6] Xinhao Liu, Masayuki Tanaka and Masatoshi Okutomi,"Noise Level Estimation Using Weak Textured Patches of a Single Noisy Image",Proceedings of IEEE International Conference on Image Processing (ICIP2012), September, 2012.

[7] A. Deledalle, J. Salmon, A. S. Dalalyan, "Image denoising with patch based PCA: local versus global"British Machine Vision Conference (BMVC), 2011.

[8] Christopher M. Bishop, "Bayesian PCA" Advances in Neural Information Processing Systems, Vol(11), pp.(382–388),January 1998.

[9] K.Rank, M.Lendl, and R.Unbehauen, "Estimation of image noise variance," IEEE Proceedings - Vision, Image, and Signal processing, vol. 146, pp. 80, 1999

[10] AishyAmer, Amar Mitiche, and Eric Dubois, "Reliable and fast structure-oriented video noise estimation," International Conference on Image Processing, vol. 51, pp. 840–843, 2002.

[11] Angelo Bosco, ArcangeloBruna, Giuseppe Messina, and Giuseppe Spampinato "Fast Method for Noise Level Estimation and Integrated Noise Reduction," IEEE Transactions on Consumer Electronics, vol. 51, pp. 1028 - 1033, Feb. 2005.

[12] PatilJyotsna, JadhavSunita," A Comparative Study of Image Denoising Techniques", International Journal of Innovative Research in Science, Engineering and Technology, ISSN: 2319-8753 Vol. 2, Issue 3, March 2013, Page(s): 1-8.

[13] Suresh Kumar1,"Performance Comparison of Median and Wiener Filter in Image De-noising" International Journal of Computer Applications (0975 – 8887) Volume 12– No.4, November 2010

[14] Addison, P. S: *The Illustrated Wavelet Transform Handbook*,Institute of Physics, 2002

[15] Ravishankari, S., and Uma, B. V.: Application of Stationary Wavelet Transform for Improvement of Rate-Reach Performance in ADSL Interference Environment, *Journal of Wavelet Theory and Applications*, vol. 2, pp. 83-92, 2008

[16] Vidakovic, B.: *Statistical Modelling by Wavelets (Wiley Series in Probability and Statistics)*, John Wiley&Sons, New York, 1999

[17] Mukesh C. Motwani "Survey of Image Denoising Techniques" Image Process Technology, Inc. 1776 Back Country Road1776 Reno, NV 89521 USA

[18] Priti Naik and Shalini Bhatia" Image Denoising Using Curvelet Transform", Proceedings of SPIT-IEEE Colloquium and International Conference, Mumbai, India vol.1,116.

[19] Poonam S. Deokar and Amruta. R. Kaushik "Medical Image Denoising using Independent Component Analysis" Proceeding of international conference on modelling and simulation in engineering & technology (ICMSET-2014),february,2014

[20] Chandrika Saxena, Prof. Deepak Kourav "Noises and Image Denoising Techniques: A Brief Survey" Proceeding of International Journal of Emerging Technology and Advanced Engineering ,Volume 4, Issue 3, March 2014


## Author Profile


**Jagdish Patel** received the B.E degrees in Computer Science &Engg. From Kirodimal Institute of Technology Raigarh, 2012 and currently pursuing M. Tech in Computer Science and Engineering,

**Mr. Rekhansh Rao** is working as a Assistant Professor, Department of Computer Science and Engineering, Rungta collage of engineering & technology. Bhilai, India