Principle Component Based Image De-Noising using Local Pixel Grouping

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Abstract— This paper presents an efficient image de-noising scheme by using principal component analysis (PCA) with local pixel grouping (LPG). For a 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. This paper also describes how PCA best as compared to mean, median and dwt filters.

Key words: Principal Component Analysis, Local Pixel Grouping, De-Noising, Filter and Discrete Wavelet Transform

I. INTRODUCTION

The de-noising phenomenon goal is to remove the noise while retaining the maximum possible the important signal or image features. At the time of acquisition and transmission the images are often corrupted by additive noise. The main aim of a de-noising algorithm is to reduce the noise level, while preserving the image features. To achieve a good performance in this respect, a de-noising algorithm has to adapt to image is continuities. Generally the quality of image can be measured by the peak signal-to-noise ratio (PSNR). However, sometimes a de-noised image with a high PSNR value does not have satisfactory visual quality.

- LPG-PCA: The LPG-PCA algorithm consists of two stages. The first stage yields an initial estimation of the image by removing most of the noise and the second stage will further refine the first stage output.
- Mean filter: A mean filter acts on an image by smoothing it; that is, it reduces intensity variation between adjacent pixels. The mean filter is nothing but a simple window spatial filter that replaces the centre value in the window with the average of all the neighbouring pixel values including it.
- Median filter: A median filter belongs to the class of nonlinear filters unlike the mean filter. A 3x3, 5x5 or 7x7 kernel of pixels is scanned over pixel matrix of the entire image. The median of the pixel values in the window is computed and the centre pixel of the window is replaced with the computed median.
- DWT: The wavelet transform provides a time frequence representation of the signals. It was developed to overcome the previous method, short time fourier transform (STFT), which can also be used to analye non stationary time signals.

II. RELATED WORK

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. The focus was shifted to Wavelet domain from spatial and Fourier domain.

Manoj Gabhel1[2] preferred working in Wavelet domain 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 (i.e., noisy coefficients) the image is reconstructed by using inverse DWT. As a result, noise is removed or filtered from the observations.

Y.Murali[3] describe that 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.

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.

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.

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.

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.

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.

III. SYSTEM MODEL

A. PCA-LPG:

This proposed LPG-PCA algorithm consists of two stages. The first stage yields an initial estimation of the image by removing most of the noise and the second stage will further refine the first stage output. In PCA-LPG based image denoising method most of the computational cost spends on LPG grouping and PCA transformation and thus complexity mainly depends on two parameters: the size of k of variable block and size L of training block. The proposed LPGPCA algorithm can be viewed as a completion and extension of the PCA based de-noising algorithm. The first step is to select any image; it may be coloured or gray-scale image. Then we will add noise of our choice, preferably additive Gaussian noise. You may also add salt and pepper noise. Then we will employ local pixel grouping method followed by principal component analysis algorithm. The output of this first stage is the input of second stage. Again local pixel grouping method followed by principal component analysis algorithm is applied, as shown in fig1 and fig2.

1) Steps for PCA

- Take sample matrix X
- Calculate mean value $\mu_i = \frac{1}{n}\sum_{i=1}^{n} X_i(j)$
- Centralise the sample vector $\overline{X}_i = X_i - \mu_i$
- Calculate covariance matrix using formula $\Omega = \frac{1}{n}\overline{X}\overline{X}^{\mathrm{T}}$
- For symmetrical covariance matrix $\Omega = \phi\Lambda\phi^T$
- Calculate orthogonal transformation matrix $P = \phi^T$
- De-correlate using orthogonal transformation matrix P as Y=PX
- A pixel and its nearest neighbours are selected as a vector variable as shown in fig.2. The training sample of this variable is selected by grouping the pixel with similar local spatial structure.

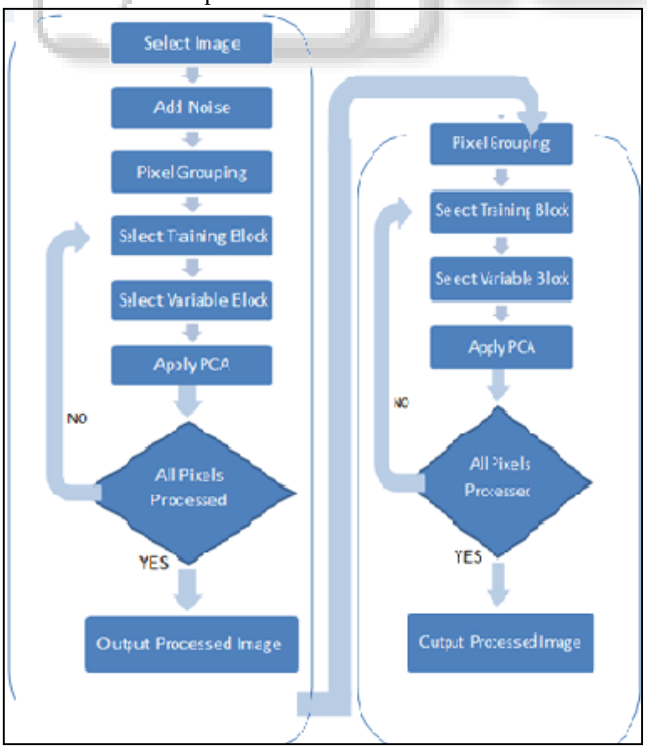

Fig. 1: LPG-PCA Algorithm

In figure 1, The procedures of both the stages have the same except for the parameter of noise level. Since the noise is significantly reduced in the first stage, the LPG accuracy will be much improved in the second stage so that the final denoising result is visually much better. The proposed LPG-PCA method is a spatially adaptive image representation so that it can better characterize the image local structures.

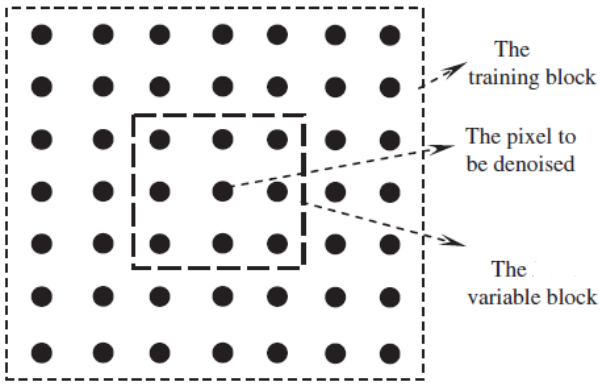

Fig. 2: Model of PCA based De-noising Using LPG

IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

For experimental results used system have processor is Intel(R) Core(TM) i3-2370 CPU@2.40GHz and RAM is 4.00GB and operating system is 64-bit.For experimental results used tool named MATLAB R2012a.

This paper define comparison between different de-noising technologies like median filter, lee filter, weiner filter, gaussain filter, discrete wavelet transform, dual tree discrete wavelet transform and principle component analysis. Table1 shows the comparison of different denoising techniques for different test images. The two stage PSNR values have taken into consideration to compare. It is clearly given that principle component analysis gives best PSNR value among all. The second stage got the better values compared to first stage. If the variance is high then second stage gives more signal-to-noise ratio values. For lower variance images first is sufficient to remove the noise.

	Monarch	amerama	House
Median	20.6154	20.8301	28.5012
Mean	25.2337	24.3735	28.3971
DWT	28.0575	28.3796	31.2737
PCA 1st	29.6746	29.4875	32.1877
PCA 2nd	30.0384	29.7061	33.0613

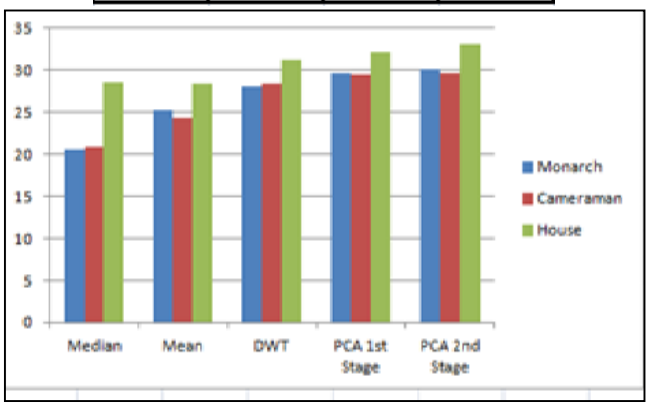

Table 1: PSNR Value Comparison

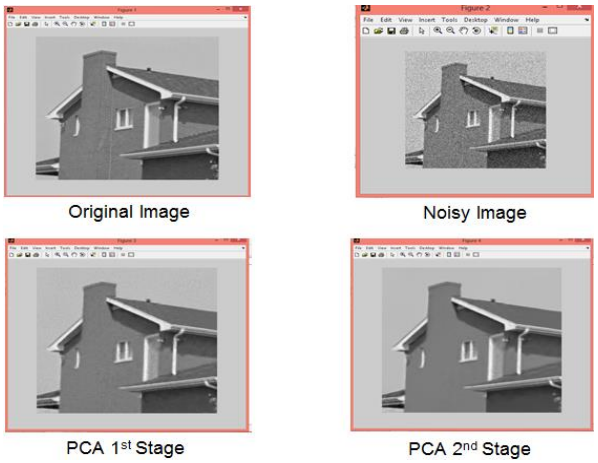

Fig. 3: Image denoised with PCA stages

- Image corrupted using Gaussian noise with mean=0.2 and standard deviation=20
- Image corrected using two stage LPG-PCA.

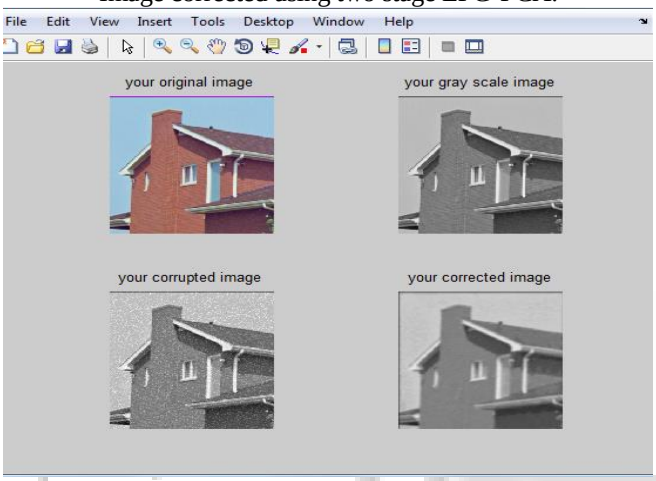

Figure4:Image denoised with mean filter

- Image corrupted using Gaussian noise with mean=0.2 and standard deviation=20
- Image corrected using mean filter.

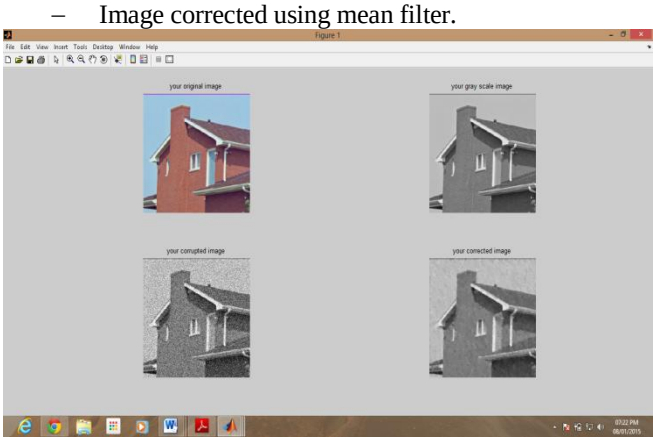

Fig. 5: Image denoised with median filter

- Image corrupted using Gaussian noise with mean=0.2 and standard deviation=20
- Image corrected using median filter.

V. CONCLUSION

This paper proposed a spatially adaptive image denoising scheme by using principal component analysis (PCA).This also define how PCA best as compared to mean and median filters by using graph. The proposed PCA-LPG denoising method employs that PCA transform with LPG in first stage. Principal component analysis adaptively calculate the vector decomposition of the target image, hence it can better represent the local structure of image and local pixel grouping, which ensure that only the right samples of pixels are needed in the training of PCA transform. Thus the overall cost of the proposed algorithm is very low and we get the denoising result in less time than that required in LPG-PCA algorithm. It provides a good compromise between the accuracy and the execution time. In this paper, we proposed a new method of PCA calculation using both LPG and eigenvector decomposition. LPG makes more difference between noise and signal from locally grouped image blocks. Then eigenvector decomposition deduct the noise. The combination of LPG and eigenvector composition makes PCA more powerful to reduce the noise from images. We applied the method in the existing LPG-PCA de-noising method. A comparison of our proposed de-noising method with the state-of-the-art de-noising methods showed that our method is much better than other methods in terms of PSNR values. We also showed that our method produced de-noised image with much better visual quality and preserved edges better than other state-of-the-art de-de-noising methods. In the future, we will implement this proposed method of PCA calculation in other fields of data analysis to see whether the proposed method of PCA calculation produces better result than existing PCA in other fields of data analysis.

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