Introduction to Wavelet Transform and Two Stage Image DE noising Using Principal Component Analysis with Local Pixel Grouping (LPGPCA) method

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Abstract— In past two decades there are various techniques are developed to support variety of image processing applications. The applications of image processing include medical, satellite, space, transmission and storage, radar and sonar etc. But noise in image effect all applications. So it is necessary to remove noise from image. There are various methods and techniques are there to remove noise from images. Wavelet transform (WT) has been proved to be effective in noise removal but this have some problems that is overcome by PCA method. This paper presents an efficient image de-noising scheme by using principal component analysis (PCA) with local pixel grouping (LPG). This method provides better preservation of image local structures. In this method 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. In image de-noising, a compromise has to be found between noise reduction and preserving significant image details. PCA is a statistical technique for simplifying a dataset by reducing datasets to lower dimensions. It is a standard technique commonly used for data reduction in statistical pattern recognition and signal processing. This paper proposes a de-noising technique by using a new statistical approach, principal component analysis with local pixel grouping (LPG). This procedure is iterated second time to further improve the de-noising performance, and the noise level is adaptively adjusted in the second stage.

Keywords: FT, WT, PCA, LPG, Noise, Pixel, De-noising.

I. INTRODUCTION

Noise is any undesired information that spoil image. In digital image noise arise during acquisition and/or transmission process. Following are different types of noise. [4]

1) Gaussian/Normal noise
2) Rayleigh noise
3) Erlang/Gamma noise
4) Exponential noise
5) Impulse/Salt and pepper noise
6) Uniform noise
7) Periodic noise

De-noising is an essential step to improve the image quality. There are different types of filters proposed for de-noising like smoothing filters, frequency domain filters, nonlinear filters etc. Wavelet transform (WT) has been proved to be effective in noise removal. [7]

II. INTRODUCTION TO WAVELET TRANSFORM (WT) AND PROBLEM WITH WT

The wavelet transformation (WT) is combination of transforms that satisfy specific conditions. So wavelet transform is a transform that have basis functions that are shifted and expended version themselves. WT contains information about both frequency information and spatial information. WT uses high pass filters, low pass filters and Fourier transformations (FT). To satisfy condition for WT the filter must be perfect Reconstruction filter which means that any distortion introduces by forward transform will be cancel in the inverse transform. Examples of this type of filters are quadrature mirror filters. The WT breaks an image down into four subsamples or decimated images. They are subsample by keeping every other pixel. The result consists of one image that has high pass filtered in both the horizontal and vertical directions. One that is high pass filter in horizontal and low pass filter in vertical. One that is high pass filter in vertical and low pass filter in horizontal. One that has low pass filtered in both directions. This transform is typically implemented in the spatial domain by using 1-D convolution filters. In order to perform the wavelet transform using convolution filters a special type of convolution called circular convolution must be used. Circular convolution is performed by taking the underlying image array and extending it in a periodic manner to match with symmetry implied by the discrete Fourier transform. The convolution process start with origin of image and convolution masked aligned, So that the first value contains contributions from the previous copy of periodic image. This is important because we may want to perform the wavelet transform on small blocks and eliminating outer row(s) and column(s) is not practical. There are various filters can be used to implement WT. The two most commonly used are Daubechies and Haar. [1]

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. [3]

III. INTRODUCTION TO PRINCIPAL COMPONENT ANALYSIS (PCA) AND LOCAL PIXEL GROUPING (LPG)

The central idea of principal component analysis (PCA) is to reduce the dimensionality of a data set consisting large number of interrelated variables while retaining as much as possible of the variation present in data set. This is achieved by transforming to a new set of variables the principal components (PCs), which are uncorrelated and which are ordered so that the first few retain most of the variation present in all of the original variables. [2]

Principal component analysis (PCA) is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of uncorrelated variables called principal components. [6] The number of principal components is less than or equal to the number of original variables. This transformation is defined in such a way that the first principal component has as high a variance as possible and each succeeding component in turn has the highest variance possible under the constraint that it be orthogonal to the preceding components. Principal components are guaranteed to be independent only if the data set is jointly normally distributed. PCA is sensitive to the relative scaling of the original variables. Depending on the field of application, it is also named the discrete Karhunen– Loève transform (KLT), the Hotelling transform or proper orthogonal decomposition (POD). PCA can be done by eigenvalue decomposition of a data covariance matrix or singular value decomposition of a data matrix, usually after mean centering the data for each attribute. [5]

Following fig-1 illustration of the modeling of LPGPCA based de-noising. [3] [9]

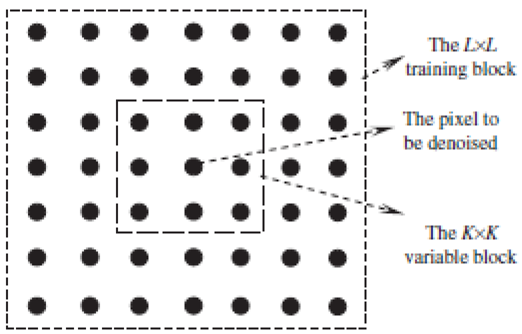

Fig. 1: Illustration of the modeling of LPGPCA based de-noising

Grouping the training samples similar to the central KxK block in the LxL training window is indeed a classification problem and thus different grouping methods, such as block matching, correlation-based matching, K-means clustering, etc., can be employed based on different criteria. Among them, the block matching method may be the simplest yet very efficient one. It employ as LPG. [3]

IV. FLOWCHART

Following fig-2 shows the flowchart for two stages LPG-

PCA de-noising scheme

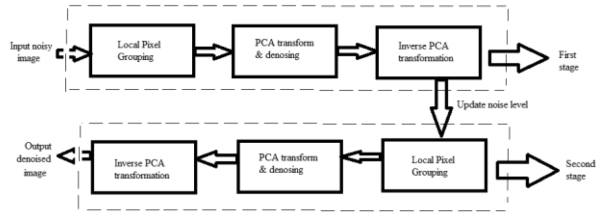

Fig. 2: Flowchart for proposed two stage LPGPCA de-noising scheme

A. ALGORITHM

Following are steps.

[1] First step is to take noisy image.
[2] Second step is to local pixel grouping.
[3] Third step is to PCA transform and de-noising.
[4] Fourth step is to Inverse PCA transform. Calculate PSNR, SSIM, and COC.
[5] Fifth step is update noise level & local pixel grouping.
[6] Sixth step is to PCA transform and de-noising.
[7] Seventh step is to Inverse PCA transform. Calculate PSNR, SSIM, and COC.
[8] Eighth step is to obtain de-noised image.

V. EXPERIMENT RESULTS

In proposed algorithm 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. Following table – I show experiment values for different black-white images and table – II shows color images. Here we have experiment on different types of images like TIF, JPG, GIF, BMP, PNG etc. The PSNR (Peak Signal to Noise Ratio) use to measure the intensity difference between two images. Generally quality of image can be measured by PSNR. [8] SSIM(Structural Similarity Index) use to measure image visual quality assessments. It shows structural similarity between the target image and reference image. COC shows the value for coefficient of correlation.

Images	First Stage			Second Stage		
	PSNR	SSIM	COC	PSNR	SSIM	COC
House.tif	38.1450	0.9403	0.9958	38.7695	0.9485	0.9963
Cameraman.tif	36.2655	0.9465	0.9962	36.7164	0.9515	0.9965
Lena.tif	36.4284	0.9492	0.9952	36.9859	0.9549	0.9956
Monarch.tif	36.5288	0.9698	0.9951	36.9958	0.9706	0.9954
HumanBrain.jpg	30.0698	0.9571	0.9945	30.1558	0.9630	0.9946
Man.gif	29.0624	0.9118	0.9837	29.1161	0.9148	0.9839
Boat.bmp	30.9432	0.9028	0.9880	30.9949	0.9052	0.9881
Pioneers.png	30.7798	0.9130	0.9924	30.7910	0.9197	0.9924

Table (1): LPGPCA for black-white images

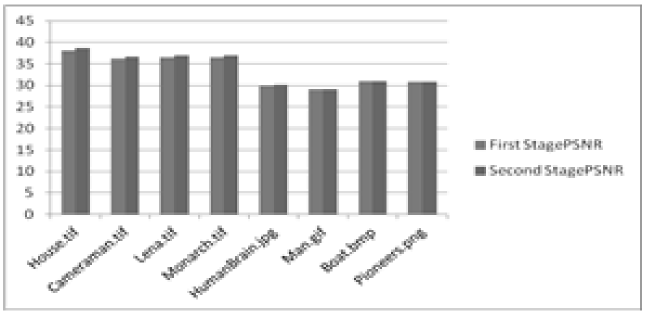

Fig. 3: Comparison of first stage PSNR & second Stage PSNR for black-white images

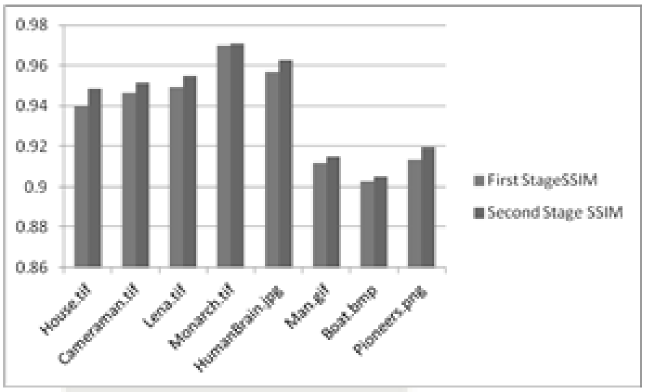

Fig. 4: Comparison of first stage SSIM & second Stage SSIM for black-white images

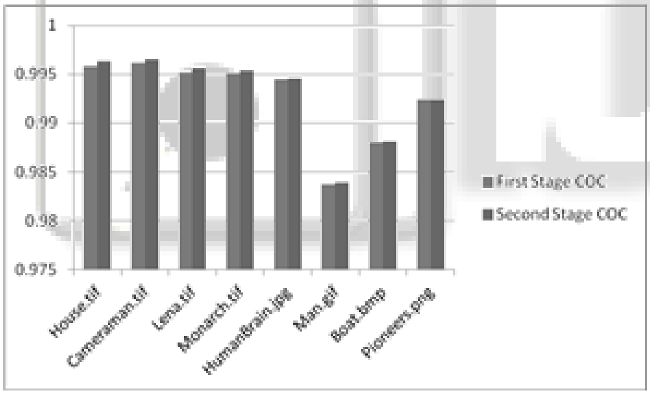

Fig. 5: Comparison of first stage COC & second Stage COC for black-white images

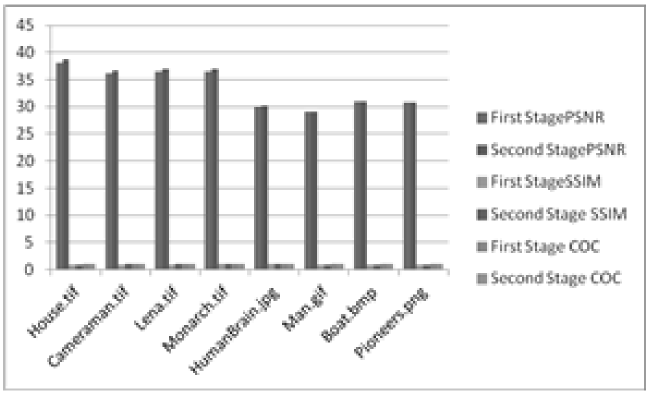

Fig 6: Comparison of first stage PSNR,SSIM, COC & second Stage PSNR,SSIM, COC for black-white images

Images	First Stage			Second Stage		
	PSNR	SSIM	COC	PSNR	SSIM	COC
Parrot.tif	34.7883	0.8868	0.9975	36.0763	0.9230	0.9981
House_color.tif	34.4500	0.8610	0.9940	35.4594	0.8934	0.9953
P_bar.tif	34.1764	0.9230	0.9943	35.2873	0.9448	0.9956
Bar.tif	34.2770	0.9142	0.9953	35.4265	0.9394	0.9964
Banana.jpg	35.9718	0.8868	0.9973	38.0346	0.9474	0.9983
Lena_color.jpg	34.0002	0.9031	0.9930	35.0126	0.9313	0.9945
Bike.bmp	33.0555	0.9403	0.9953	33.8820	0.9542	0.9961
Tree.png	29.8007	0.9622	0.9904	29.8819	0.9630	0.9906

Table (2): LPGPCA for color images

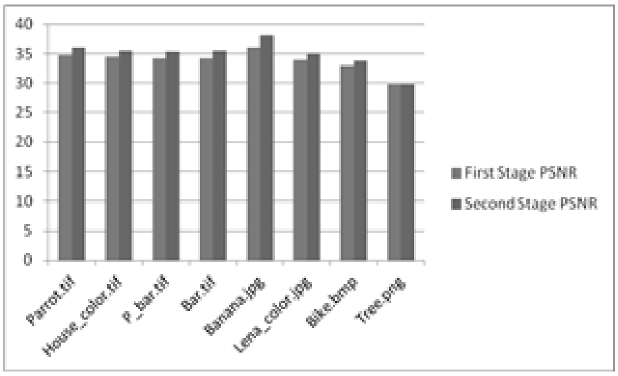

Fig. 7: Comparison of first stage PSNR & second Stage PSNR for color images

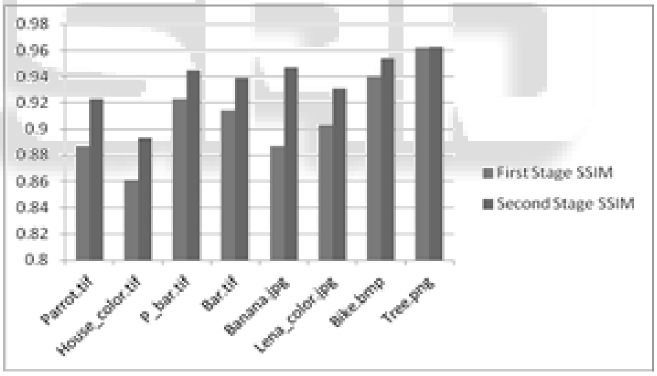

Fig. 8: Comparison of first stage SSIM & second Stage SSIM for color images

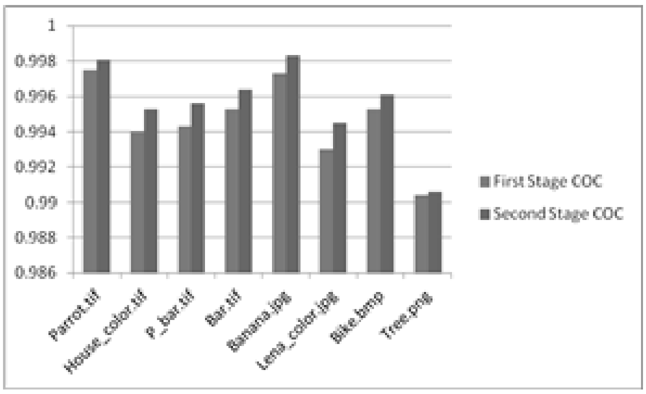

Fig. 9: Comparison of first stage COC & second Stage COC for color images

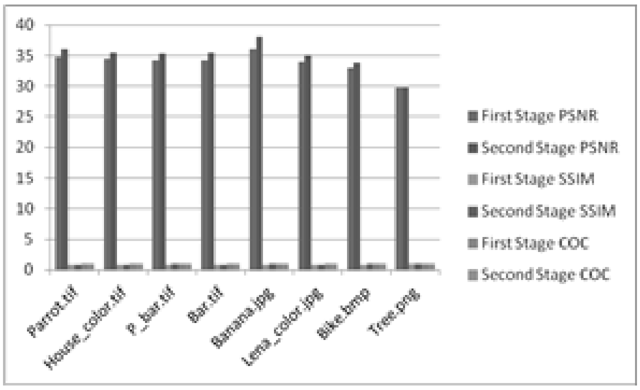

Fig. 10: Comparison of first stage PSNR,SSIM, COC & second Stage PSNR,SSIM, COC for color images

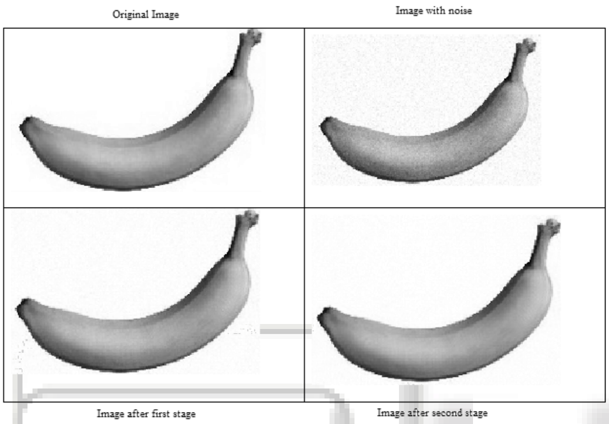

Fig. 12: Banana image (color) various stage

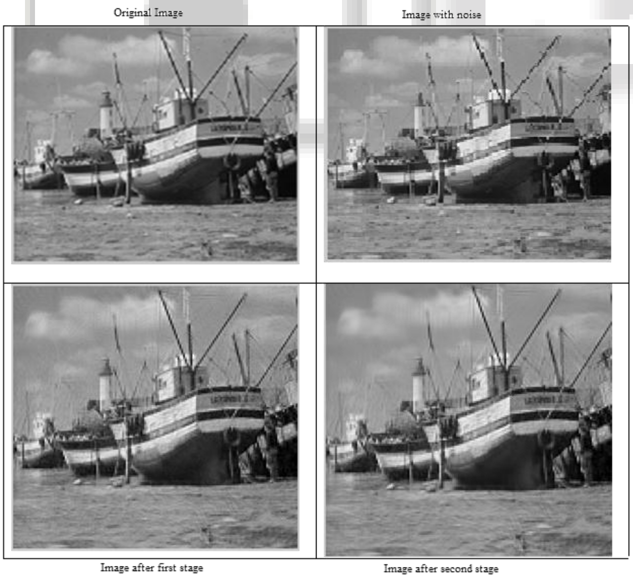

Fig. 12: Boat image (black-white) various stage

VI. CONCLUSION

The LPGPCA technique given in this paper is useful with all types of images like jpg, gif, tiff, bmp etc., it also work with any size of image like 256x256 etc., But as size of image increase it take more time because it have to work with more number of pixels So further improvement can be done in this direction. Additional this paper provides various parameters to measure like PSNR, SSIM and COC.

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