

Multi-channel Image Deblurring using Blind Deconvolution

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Abstract The proposed restoration involves a DCT domain zonal filtering pre-processing followed by a post-processing step of time domain deconvolution. The technique applies to situations on which the scene consists of a finite support object against a uniformly black, gray or white and color backgrounds. Preliminary simulations in noise-free and noisy cases are conducted. The results are compared with standard Median filter for image denoising and the proposed blind restoration scheme is shown to exhibit improvement in SNR.

1 INTRODUCTION:

The process of simultaneously estimating the PSF and restoring an unknown image using partial or no information about the imaging system is known as Blind Image restoration. For the linear degradation model when the noise item is neglected, it is specially referred to as blind deconvolution. There exit several motivating factors for the use of blind deconvolution in image processing applications. In many situations, it is difficult to accurately measure the degradation using calibration or on-line identification techniques; in addition, it is costly, dangerous, or physically impossible to obtain a priori information about the scene to be imaged. For example, in remote sensing and space imaging, fluctuations in the PSF are difficult to characterize as a random process, and there is difficulty in statistically modeling the original image. In addition, the use of adaptive optics system is often too expensive for some observation facilities, and the potential for phase error exists with cheaper partially compensating systems. Thus, technique such as blind deconvolution will be required.

2. FLOWCHART FOR THE ITERATIVE MULTICHANNEL BLIND IMAGE RESTORATION:

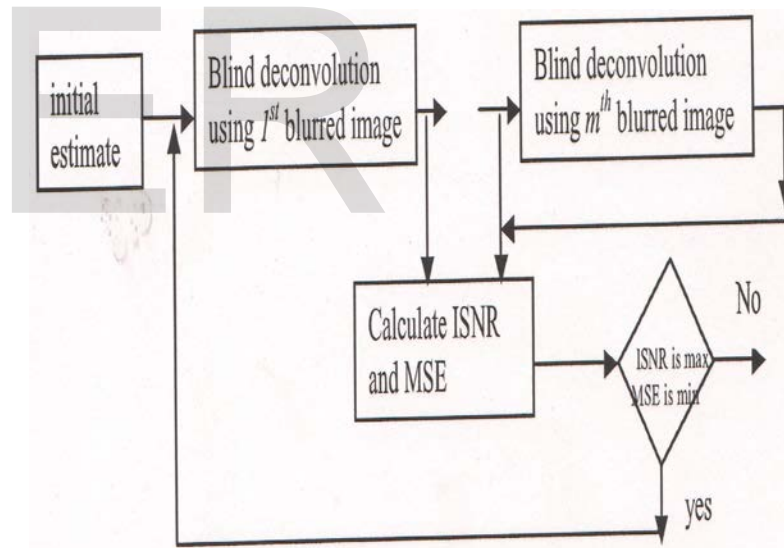


Fig: 1 Iterative Multi-channel blind image restoration

2.1 Iterative Multi-channel Blind image Restoration

Computer simulation results are shown in the section 2.2 for multi-channel blind restoration using blind deconvolution. Classical Lena and Barbara colored images shown in fig 3 were chosen as test images. Three blurred channels of the same original image are considered. The images are

blurred with motion blur at an angle of 20,30,40 degrees. The blurred images are passed through a deblurring filter iterative blind deconvolution. In case of blind deconvolution the blur function or the Point Spread Function (PSF) is unknown or very little statistical information is available about the original image. An initial guess on the PSF is made the guessed PAF is convolved with the degraded image in order to obtain an estimate of the true image. The Improvement in Signal to Noise Ratio (ISNR) and Mean Square Error (MSE) is found. The experiment is repeated until we get a appropriate guess of PSF for which the ISNR is maximum and MSE is minimum. This final PSF is then deconvolved with the degraded image in order to obtain the estimate of true image. These steps are repeated for all the channels in order to obtain the restored images; from the multiple restored images a single output image is obtained which satisfies most of the assumption made about the true image.

2.2 Simulation Results:

1. Single-Input Multi-Output:- Lena Image



Fig.2 a: Original Lena image with SNR- 25 dB for 1st Channel, SNR -20 dB for 2nd Channel and SNR=15dB for 3rd channel

II. Multi-Input Single-Output:- Lena Image



Fig.2b: Restored Lena with ISNR1=5.6260dB for 1st channel, ISNR2=5.2743dB for 2nd channel, ISNR3=5.0615dB for 3rd channel and MSE=189

I. Single-Input Multi-Output:- Barbara Image



Fig 3a: Original Barbara image with SNR -25dB for 1st channel, SNR-20 dB for 2nd channel, SNR=15dB for 3rd channel

II. Multi-Input Single-Output:- Barbara Image



Fig3b: Restored Barbara with ISNR1=2.3492dB for 1st channel, ISNR2=2.6013 dB for 2nd channel, ISNR=2.7203dB for 3rd channel and MSE=393.91

3. Multichannel Image Denoising Using Zonal Filter

The presence of noise is visually annoying and makes it more difficult to perform tasks such as image restoration, segmentation, recognition, and scene interpretation. It then becomes desirable to construct a good estimate of the original image from the blurred noisy observations. Initially Median filters were considered to remove the noise present in the image. Median filters effectively remove the noise by substituting the pixel position with the median of the input data. Intuitively the filtering should be applied only to the corrupted pixels while leaving those uncorrupted ones intact.

We have proposed a new noise removal technique called zonal coding or zonal filter for multichannel color images. A zonal mask is applied to the low frequency components and higher frequency components are discarded. Thus the noise, which is present in the image, is filtered or removed. Experimental results show that Zonal filters have proven to achieve a good performance over Median filters.

3.1 Flow chart Multichannel images using zonal filter

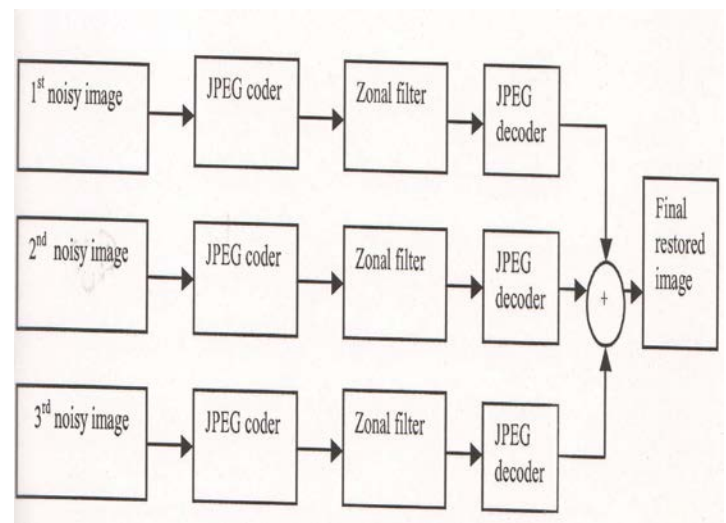


Fig4: Multi-Channel restoration using zonal filter

Computer simulation results for multichannel colored image denoising using zonal filter are shown in section 3.2. The classical Lena and Barbara colored images shown in fig 4.3 were chosen as test images. Initially the experiments were carried with median filters and the results were compared with zonal filters.

Three different noisy versions of the test image were considered which were corrupted by AWGN (SNR=25dB, SNR=20dB and SNR=15dB). Then the degraded or the noisy images were compressed into a JPEG format. Zonal mask shown in the fig 4.2a was applied i.e., 8x8 block DCT was considered and the mask was applied only to the lower frequency components and the higher frequency components were discarded as most of the noise resides in the higher frequency components. Thus the noise, which is present in the image, is removed to greater extent. This process is applied to all the blocks of the entire image. The resultant images were subjected to inverse DCT and the images obtained were the estimate of the true image. Finally from the multiple-channels a single output image is obtained which satisfies most of the assumption made about the true image.

3.2 Simulation Results:

1. Single-Input Multi-Output:- Lena Image (Median Filter)

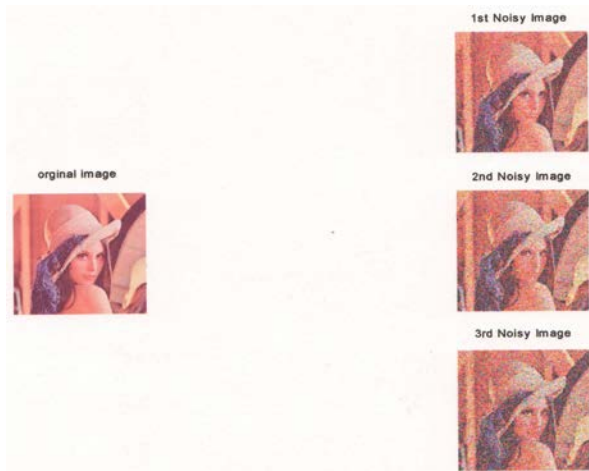


Fig5a: original Lena using Median filter with SNR-25dB for 1st channel, SNR-20dB for 2nd channel and SNR-15dB for 3rd channel

II Multi-Input Single-output:- Lena Image (Median Filter)



Fig5b: Restored Lena with ISNR1=2,456dB for 1st channel, ISNR2=3.5840dB for 2nd channel, ISNR3=4.0231dB for 3rd channel and MSE=280

I. Single-Input Multi-Output:-Lena image (Zonal Filter0.25 BR)



Fig 6a: Original Lena using zonal filter with SNR-25dB for 1st channel, SNR-20dB for 2nd channel and SNR-15dB for 3rd channel at 0.25 Bit Rate

II. Multi-Input Single-Output:- Lena Image (Zonal filter0.25 BR)



Fig6b: Restored Lena with ISNR1=4.9935dB for 1st channel, ISNR2=5.5840dB for 2nd channel, ISNR3=6.0231dB for 3rd channel and MSE=199

I. Single-Input Multi-Output:- Barbara Image (Median Filter)

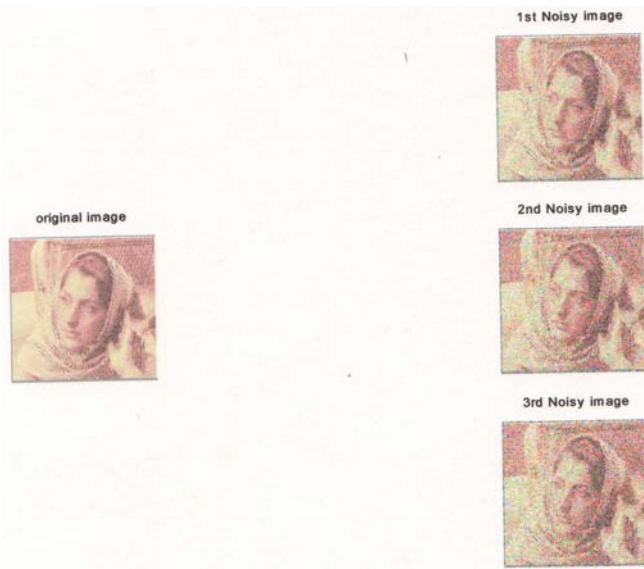


Fig 7a: Original Barbara using Median filter with SNR-25dB for 1st channel, SNR-20dB for 2nd channel and SNR-15dB for 3rd channel

I. Single-Input Multi-Output:- Barbara Image (Zonal Filter)



Fig 8a: original Barbara using zonal filter with SNR-25dB for 1st channel, SNR-20dB for 2nd channel and SNR-15dB for 3rd channel for 0.25 Bit Rate

I. Multi-Input Single-Output:- Barbara Image (Median Filter)

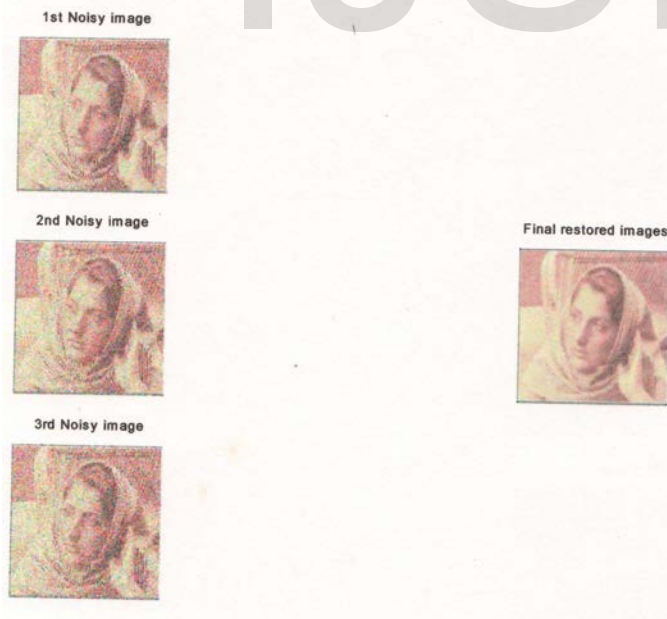


Fig7b: Restored Barbara with ISNR1=26.41dB for 1st Channel, ISNR2=3.5840dB for 2nd channel, ISNR3=3.9912dB for 3rd channel and MSE=480

I. Multi-Input Single-Output:- Barbara Image (Zonal Filter)



Fig. 8b: Restored Barbara with ISNR1=3.5497dB for 1st channel, ISNR2=4.4923 for 2nd channel, ISNR3=5.9945 for 3rd channel and MSE=420.54

4. Multichannel Restoration of Blurred Noisy Images using Zonal Filter

The proposed Multi-Input Single-Output model of section 4.6 is used for restoring blurred noisy images. Computer simulation results for multichannel restoration of blurred noisy colored image using zonal filter is shown in section 4.1. The classical Lena and Barbara colored images shown in fig 4.3 were chosen as test images. Initially the experiments were carried with median filters and the results were compared with zonal filters.

Three different Blurred Noisy versions of the test image were considered which were corrupted by AWGN and motion blur (BSNR1-60dB for 1st channel, BSNR2-40dB for 2nd channel and BSNR3-50dB for 3rd channel), which is represented by.

$$g(x, y) = f * m = \sum_{k=0}^{k-1} m_k \cdot f(x + k \cos(\alpha), y + k \sin(\alpha))$$

Where 'g' denote the observed image, degraded by a motion blur with a done dimensional kernel $m=(m_1, \dots, m_K)$ at an angle α , 'f' the original image degraded according to Eq(5.1). The motion blur in each channel is assumed at an angle of 20,30 and 40 degrees. The blurred nosy images were compressed into a JPEG format. Zonal mask was applied to the blurred nosy versions in order to remove the noise contained in it i.e., 8x8 block DCT was considered and the mask was applied only to the lower frequency components and the higher frequency components were discarded as most of the noise resides in the higher frequency components. Then inverse DCT is applied to obtain the noise free image. In order to remove the blur, the deblurring filter i.e., Blind deconvolution was applied, this process was repeated to three different channels. Finally from the three multi-channels a single restored image is obtained by linear combination, which fulfills most of the assumptions made about the true image. Thus the proposed restoration model involves a pre-

processing DCT domain zonal followed by a post-processing step of time domain deconvolution.

Experimental results show that zonal filters have proven achieve a greater noise reduction when compared to other noise reduction technique such as median filter.

4.1 Simulation results:

I. Single-Input Multi-Output:- Lena Image (Median Filter)



Fig9a: original Lena using Median filter with BSNR1-60dB for 1st channel, BSNR-2-40dB for 2nd channel and BSNR3-50dB for 3rd channel.

II. Multi-Input Single-Output:- Lena Image (Median Filter)



Fig9b: Restored Lena with ISNR1=3.3946dB for 1st channel, ISNR2=3.9642dB for 2nd channel and ISNR3=4.3261dB 3rd channel and MSE=203.

I. Single-Input Multi-Output:- Lena Image (Zonal Filter-0.25 BR)



Fig10a: Original Lena using Zonal filter with BSNR1-60dB for 1st channel, BSNR2-40dB for 2nd channel and BSNR3-50dB for 3rd channel at 0.25 Bit Rate.

I. Single-Input Multi-Output:- Lena Image (Zonal Filter-0.39 BR)



Fig11a: original Lena using zonal filter with BSNR1-60dB for 1st channel, BSNR2-40dB for 2nd channel and BSNR3-50dB for 3rd channel at 0.39 Bit Rate.

II. Multi-Input Single-Output:- Lena Image (Zonal Filter-0.25 BR)



Fig10b: Restored Lena with ISNR1=4.1172dB for 1st channel, ISNR2=6.3681dB for 2nd channel and ISNR3=5.0599dB for 3rd channel and MSE=169.89.

II. Multi-Input Single-Output:- Lena Image (Zonal Filter-0.39 BR)

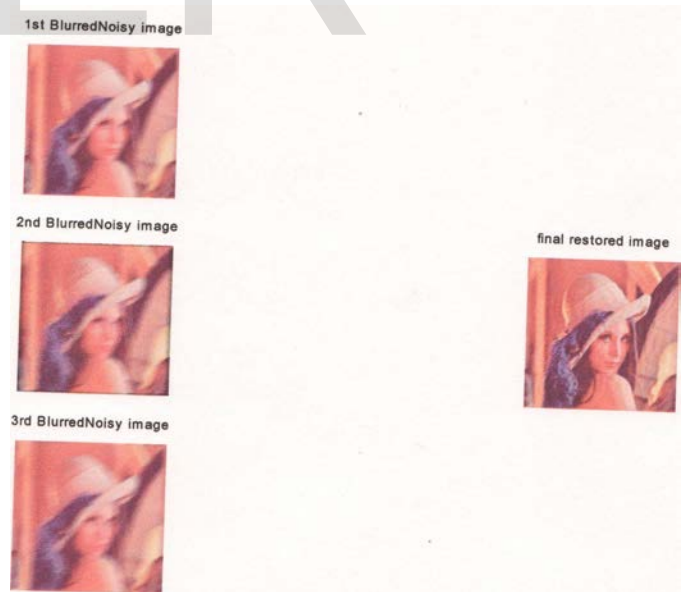


Fig11b: Restored Lena with ISNR1=4.0477dB for 1st channel, ISNR2=6.32633dB for 2nd channel and ISNR3=4.9955dB for 3rd channel and MSE=173.2827.

I. Single-Input Multi-Output:- Lena Image (Zonal Filter-0.56BR)

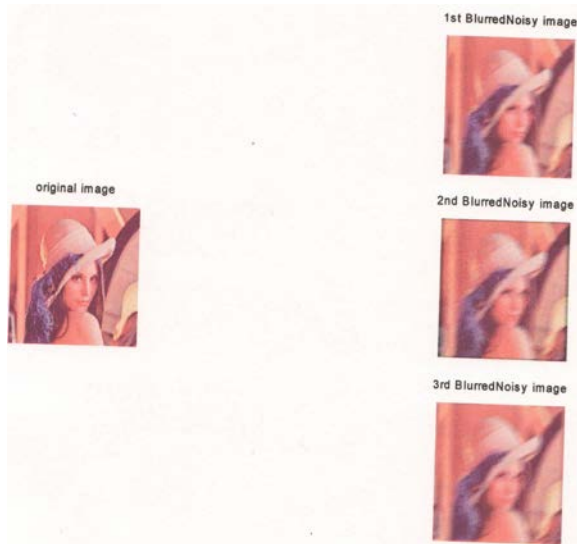


Fig12a: original Lena using zonal filter with BSNR1-60dB for 1st channel, BSNR2-40dB for 2nd channel and BSNR3-50dB for 3rd channel at 0.56 Bit Rate.

II. Multi-Input Single-Output:- Lena Image (Zonal Filter-0.56 BR)



Fig12b: Restored Lena with ISNR1=3.6558dB for 1st channel, ISNR2=5.9166dB for 2nd channel and ISNR3=4.0685dB for 3rd channel and MSE=189.

I. Single-Input Single-Output:- Barbara Image (Median Filter)



Fig 6a: original Barbara using Median filter with BSNR1-60dB for 1st channel, BSNR2-40dB for 2nd channel and BSNR3-50dB for 3rd channel.

II. Multi-Input Single-Output:- Barbara Image (Median Filter)



Fig6b: Restored Barbara with ISNR1=1.639dB for 1st channel, ISNR2=1.2486dB for 2nd channel and ISNR3=1.2292dB for 3rd channel and MSE=498.

I. Single-Input Multi -Output:- Barbara Image (Zonal Filter-0.25 BR)



Fig 6.1a: original Barbara using zonal filter with BSNR1-60dB for 1st channel, BSNR2-40dB for 2nd channel and BSNR3-50dB for 3rd channel at 0.25 Bit Rate.

II. Multi-Input Single-Output:- Barbara Image (Zonal Filter-0.25 BR)



Fig6.1b: Restored Barbara with ISNR1=1.9930dB for 1st channel, ISNR2=2.8336dB for 2nd channel and ISNR3=1.5827dB for 3rd channel and MSE=459.

I. Single-Input Multi-Output:- Barbara Image (Zonal Filter 0.39 BR)



Fig6.2a: original Barbara using zonal filter with BSNR1-60dB for 1st channel, BSNR2-40dB for 2nd channel and BSNR3-50dB for 3rd channel at 0.39 Bit Rate.

II. Multi-Input Single-Output:- Barbara Image (Zonal Filter 0.39BR)



Fig 6.2b: Restored Barbara with ISNR1=1.1857dB for 1st channel, ISNR2=3.0260dB for 2nd channel and ISNR3=1.7729dB for 3rd channel and MSE=439

I. Single-Input Single-Output:- Barbara Image (Zonal Filter 0.56 BR)



Fig6.3a: original Barbara using zonal filter with BSNR1-60dB for 1st channel, BSNR2-40dB for 2nd channel and BSNR3-50dB for 3rd channel at 0.56 Bit Rate.

I. Single-Input Multi-Output:- Sunspot Image (Median Filter)

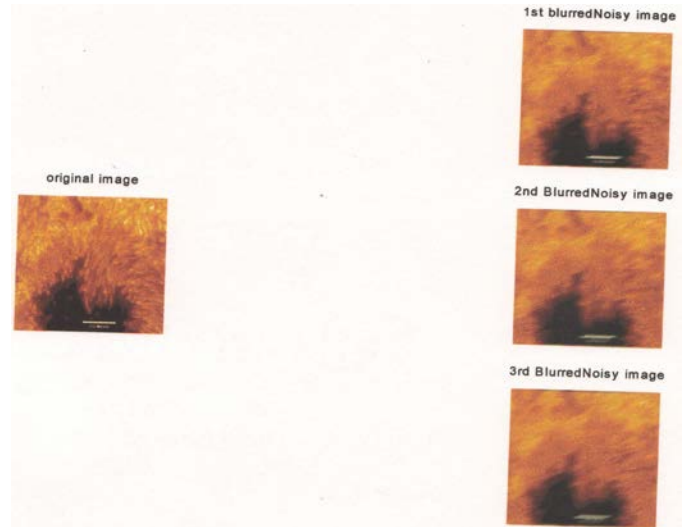


Fig6.4a: Subspot image using Median filter with BSNR1-60dB for 1st channel, BSNR2-40dB for 2nd channel and BSNR3-50dB for 3rd channel.

II. Multi-Input Single-Output:- Barbara Image (Zonal Filter 0.56BR)

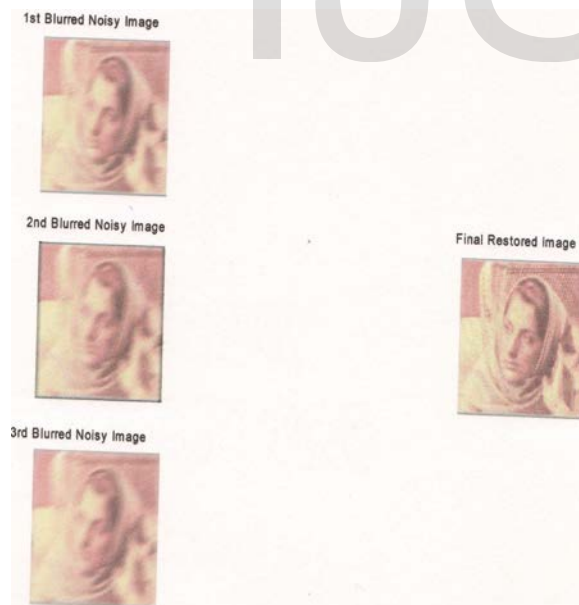


Fig 6.3b: Restored Barbara with ISNR1=1.2784dB for 1st channel, ISNR2=3.11dB for 2nd channel and ISNR3=1.8681dB for 3rd channel and MSE=430.

II. Multi-Input Single-Output:-Sunspot Image (Median Filter)

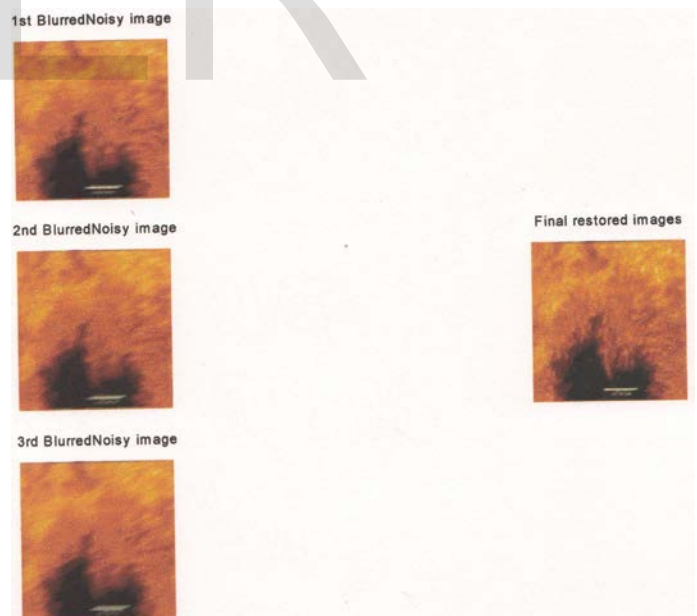


Fig6.4b: Restored sunspot image with ISNR1=1.2784dB for 1st channel, ISNR2=1.5833dB for 2nd channel and ISNR3=2.4537dB for 3rd channel and MSE=271.

I. Single-Input Multi-Output:- Sunspot Images (Zonal Filter 0.25BR)



Fig 6.5a: Subspot Image using Zonal filter with BSNR1-60dB for 1st channel, BSNR2-40dB for 2nd channel and BSNR3-50dB for 3rd channel at 0.25 Bit Rate.

II. Multi-Input Single-Output:- Sunspot Image (Zonal Filter 0.25BR)

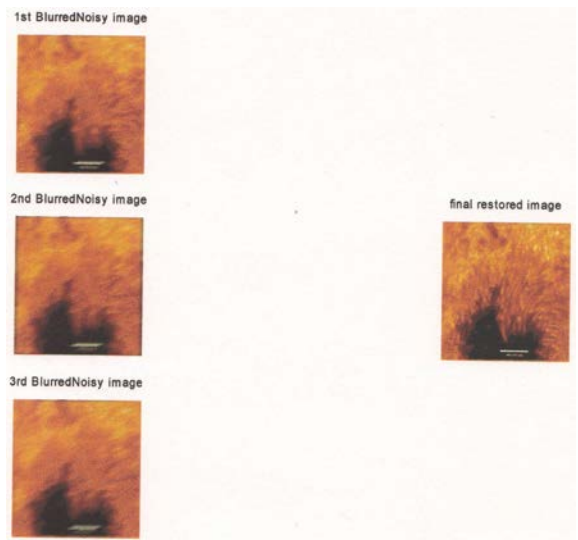


Fig 6.5b: Restored sunspot with ISNR1=2.1237dB for 1st channel, ISNR2=5.0268dB for 2nd channel and ISNR3=4.0810dB for 3rd channel and MSE=184.0398.

I. Single-Input Single-Output:- Red Blood Blood Cells (Median Filter)

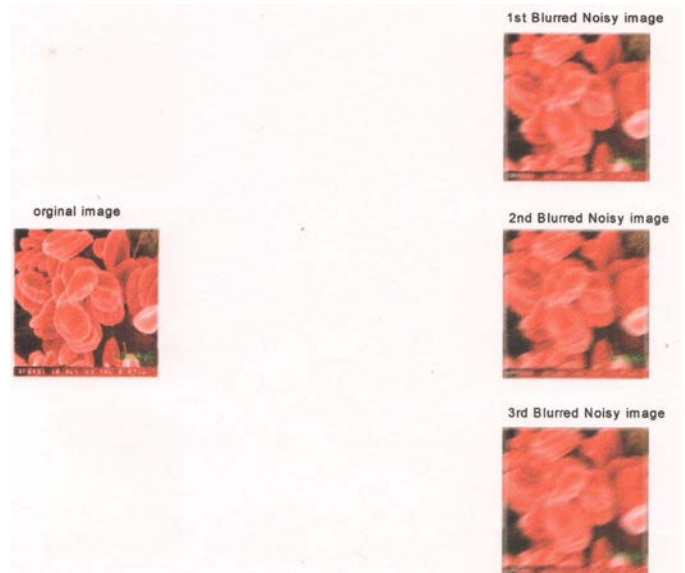


Fig6.6a: Electron Microscopic Image of Red Blood Cells using median filter with BSNR1-60dB for 1st channel, BSNR2-40dB for 2nd channel and BSNR3-50dB for 3rd channel.

II. Multi-Input Single-Output:- Red Blood Cells (Median Filter)

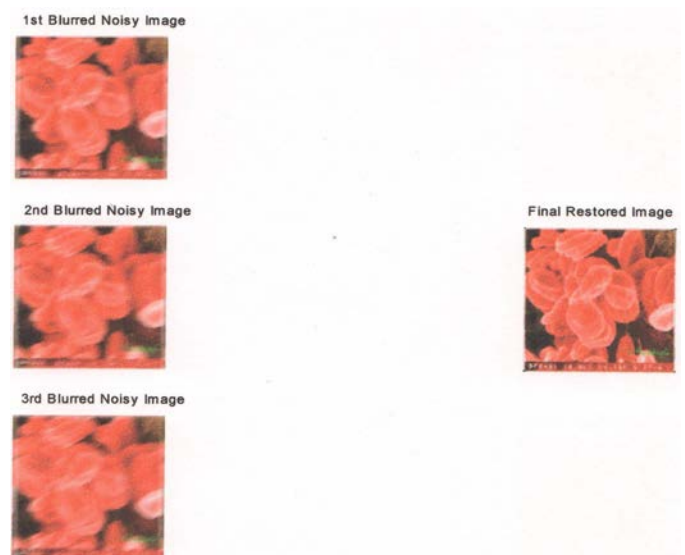


Fig6.6b: Restored Red Blood Cells with ISNR1=3.7035dB for 1st channel, ISNR2=3.4760dB for 2nd channel and ISNR3=3.2227dB for 3rd channel and MSE=385.927.

I. Single-Input Multi-Output:- Red Blood Cells (Zonal Filter-0.25 BR)



Fig6.7a: Electron Microscopic image of Red Blood Cells using zonal filter with BSNR1-60dB for 1st channel, BSNR2-40dB for 2nd channel and BSNR3-50dB for 3rd channel.

II. Multi-Input Single-Output:- Red Blood Cells(ZonalFilter0.25BR)



Fig6.7b: Restored Red Blood Cells with ISNR1=3.9184dB for 1st channel, ISNR2=6.3504dB for 2nd channel and ISNR3=5.6430dB for 3rd channel and MSE=325.871.

1. Plot for Lena Image

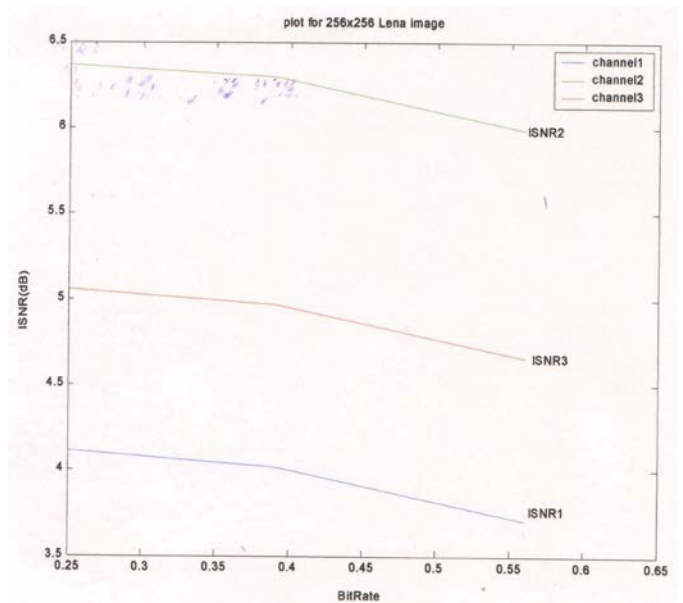


Fig6.8: Plot of ISNR's for various Bit Rates for Lena Image.

II. Plot for Barbara Image

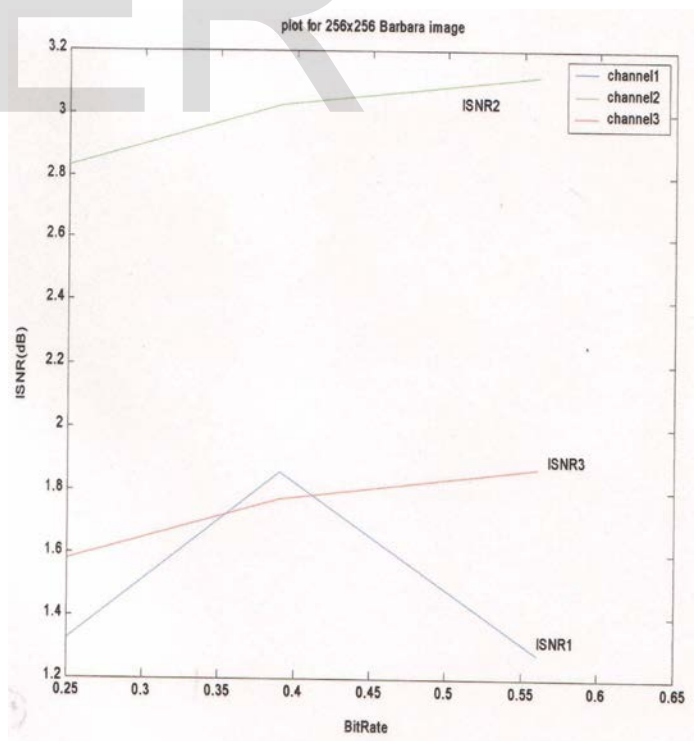


Fig.6.9: Plot of ISNR's for various Bit Rates for Barbara Image.

III. Plot for Sunspot Images

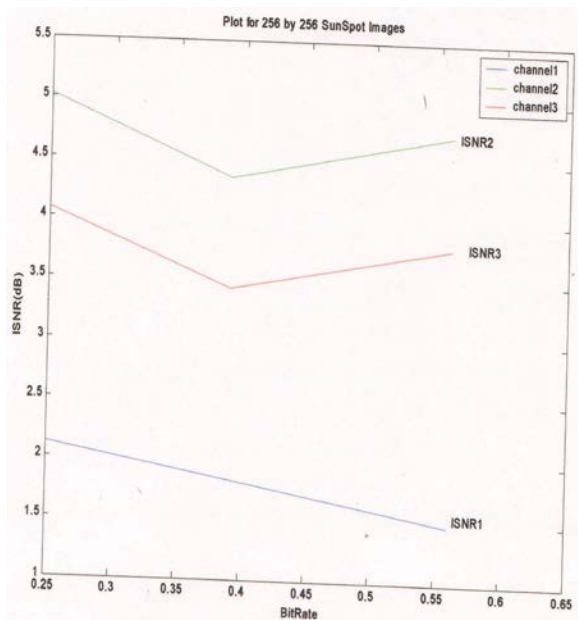


Fig 6.10: Plot of ISNR's for various Bit Rates for Sunspot Image.

IV. Plot for Red Blood Cells Images

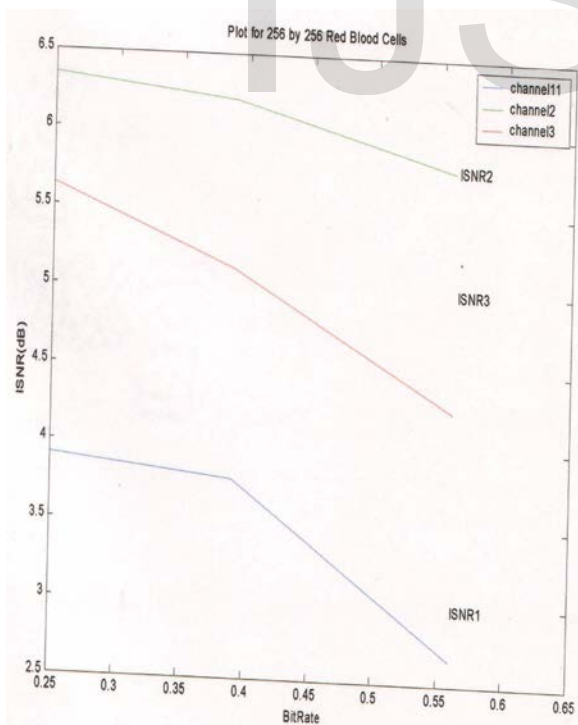


Fig.6.11: Plot of ISNR's for various Bit Rates for election microscopic red blood cells Image.

I. Lena and Barbara image ISNR's for various Bit Rates

	BR(bps) (0.25)	BR(bps) (0.39)	BR(bps) (0.56)
Lena image			
ISNR1	4.1172	4.0178	3.7062
ISNR2	6.3681	6.2994	5.9878
ISNR3	5.0599	4.9686	4.6570
ISNR_AVG	5.1817	5.0953	4.7837
Barbara image			
ISNR1	1.326	1.8570	1.2784
ISNR2	2.8332	3.0206	3.1188
ISNR3	1.5872	1.7729	1.8681
ISNR_AVG	1.9139	2.2186	2.0884

Table1: ISNR and Bit Rate values for Lena and Barbara Image

II. Sunspot and Red Blood Cells images ISNR's for various Bit Rate.

	BR(bps) (0.25)	BR(bps) (0.39)	BR(bps) (0.56)
Sun Spot image			
ISNR1	2.1273	1.4840	1.8356
ISNR2	5.0268	4.3546	4.7275
ISNR3	4.0810	3.4389	3.7913
ISNR_AVG	3.7430	3.0295	3.4515
Red Blood Cells image			
ISNR1	3.9184	3.7772	2.7956
ISNR2	6.3504	6.2096	6.1278
ISNR3	5.6430	5.5186	4.9876
ISNR_AVG	5.3039	5.1688	4.6360

Table2: ISNR and Bit Rate values for Sun Spot and Red Blood Cell Image.

5. CONCLUSION

A simple and efficient method of restoring the multi-channel colored images using pre-processing zonal filtering in DCT domain and post processing deconvolution in time domain. The advantage of the proposed method is that the restoration is done under compression. Experimental results outperform recently used median filters, having better improvement in SNR showing consistent and stable performance across a wide range of blur and noise densities. Experimental results show that the quality of the restored image is good, only when the quantity of noise is less in case of standard median filters, whereas a zonal filter tries to remove the noise even in the worst case. The algorithm is efficient in terms of reduced computation of the order of 75 percent for lower bit rates.

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