I J C T A, 9(11) 2016, pp. 5065-5072

IMPROVISED WIENER FILTER WITH COMPARISON TO WAVELET IMAGE RESTORATION ALGORITHM

Ambalika Kakoty* and Karanvir Kaur**

Abstract: Restoration in layman language refers to reconstruction. Today images are a sole source of information in any field which gives us a clear representation of concepts. Be it forensics, astronomy, medical, mechanical or circuitry, images play an important role. With the increased global digitisation images are now in digitised form which requires computers for storage and processing. As a matter of fact, they tend to get distorted either during capture due to motion blur or during transfer due to interference and noise. So, to remove the noise present in these distorted images, we need filters which cut down the unwanted signals of the degraded image and present us with a more likely form of original image. In this paper, a proposal has been set up for analysis of the two most popular and classic image restoration filters which are Wiener and Wavelet filters and their results will be compared on the basis of the parameter signal-to-noise ratio (SNR).

Key Words: Blur, Forensics, Astronomy, Image Restoration, Wiener Filter, Wavelet Filter.

1. INTRODUCTION

Images being the useful source of representation in all fields, depict more than words. Thus they require a constant way of preserving them with utmost care. Digital images are pictorial representation of the pictures clicked day-to-day in 2-D [16] form comprising of pixels stored and transferred with the help of computers. Each pixel is a picture element denoted by (x,y) coordinates. Digital Image Processing is a vast study of how the whole image processing process takes place. Any object in this universe emits some light which is a reflected part of the light falling from any natural source like sun and any artificial source like electric lights. This reflected light falls on our eyes' retina which makes it possible to see those objects. So, first the objects are detected and then they are captured in cameras leading to image acquisition. Now once the images are captured, they may either be degraded due to various factors like motion blur, due to moving camera or due to sensor factors like sensor temperature or sensor fill area [16]. When CCD (charged couple device) cameras are used, they contain a sensor which is an electric circuit. So, if the sensor gets heated, it leaks charge resulting to degradation of images. Sensor fill area also plays an important role in this degradation of images. On capture, light from the object falls in the sensor fill area.

* Assistant Professor, Department of Computer Science & Engineering, Lovely Professional University, Delhi-Jalandhar G.T Road, N.H-1, Phagwara, Punjab-144411 ambi.kakoty19@gmail.com

** M.Tech Student, Department of Computer Science & Engineering, Lovely Professional University, Delhi-Jalandhar G.T Road, N.H-1, Phagwara, Punjab-144411 ambi.kakoty19@gmail.com

But sometimes it so happens that in some parts of the fill area there is more light captured and in some parts less. This results in uneven distortion of the image leading to degradation. Images can also be degraded by factors like noise and interference during transfer. When multiple images are transferred simultaneously, they are subjected to interference which is the phenomenon of entangling of signals from various images in one medium. Thus due to this images get distorted and degraded. So, we want a mechanism to restore them back to their original form or a less likely form of the original image [11]. This is where the image restoration comes into picture. It uses filters to remove the unwanted noise and results into a more likely form of original image. During the image restoration process [10], [13], we make use of two types of filters-low pass filter and the high pass filter. The image restoration model can be depicted as-

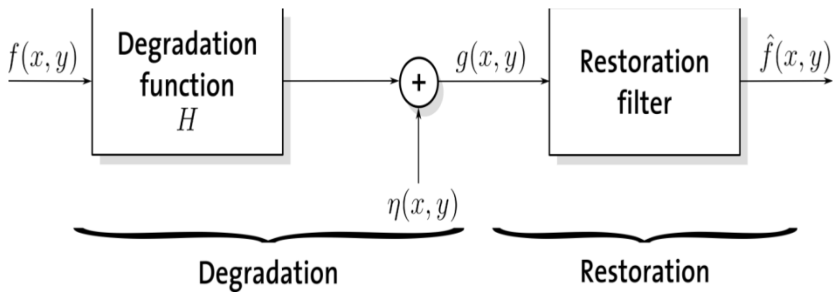

Figure 1: Image Restoration Model

Any clear image, f(x,y) is fed to a low pass filter which passes only signals with low frequency lower than cut-off frequency and attenuates signals with frequencies than that cut-off frequencies. This process can be said to be a degradation function, H. After this the noise, ƞ(x,y) is added to the image to form a degraded image. The degraded image, g(x,y) is fed to a restoration filter which is a high pass filter which allows only high frequencies greater than the cut-off frequency to pass and attenuates lower frequencies lower than the cut-off frequency. This process is called inverse filtering. In the image restoration part, apart from inverse filtering, noise is also removed. And finally, the result is a more likely form of the original image, fˆ(x,y). Mathematically, in spatial domain the whole process can be represented as-

$$g(x,y) = h(x,y) * f(x,y) + \eta(x,y)$$

and in frequency domain it is represented as-

$$G(u,v) = H(u,v) * F(u,v) + \eta(u,v)$$

Image restoration comes under the digital image processing area which is the processing of digital images. The main aim of this field is split into two points-one, store the images with less disk space and the other, send the digital images with low bandwidth. However processing of images measured by CPU time cost is also considered which needed to be minimised [9]. In image restoration, we never obtain 100% result but always get a more likely form of original image. In image restoration, we have two approaches to solve- technique where a little is known about the image known as blind approach [10]. In that approach, we model and characterize the sources of degradation and implement an estimating process designed to remove their effects. Another technique where a lot is known about the image, known as non-blind approach [10] where a mathematical model of the image is developed and then the image is fed into that model. Also, image restoration techniques can be further divided into two broad categories-deterministic and stochastic [8], [13]. Deterministic methods of restoration refer to the situations where prior knowledge about degradation is known and stochastic methods of restoration refer to the situation where no prior knowledge about the degradation of images is known. The deterministic methods are further sub-divided into two categories namely Linear and Non-Linear methods [13]. Classical linear techniques restore the true image by filtering the observed image using a properly designed filter whereas the non linear techniques restore the true image using any filter. In this paper, two filters have been highlighted namely- Wiener and Wavelet.

1.1 Wiener Filter

The Wiener filtering is not based on a single image but an ensemble of images. It makes use of correlation between two pixels in an image. If distance between two pixels is more then correlation them is very less leading to blurring effect in the image but if the distance between the pixels is very less then correlation between them is more and the image appears to be clear enough for interpretation. The Wiener filter minimises the overall mean square error in the process of inverse filtering and noise smoothing. It basically has two parts of its own implementation-inverse filtering which performs deconvolution by high pass filter and noise smoothing which removes the noise or unwanted signals from the distorted image. This filter technique is of the stochastic restoration kind. The algorithm of this wiener filter executes as follows-

Step 1: Read any clear image to test restoration process.

Step 2: Blur the image by convolution by passing it into low pass filter, degradation function.

Step 3: Add additive Gaussian noise of a certain value of variance to obtain degraded noisy image.

Step 4: The degraded image is fed to the restoration filter that is the wiener filter where two processes occur-noise smoothing or removal of noise and inverse filtering by high pass filter.

1.2 Wavelet Filter

It makes use of small waves as functions known as wavelets of varying frequencies and limited duration [3]. It makes process of compressing, transmitting and analyzing images easier. Normally if the objects are small in size or low in contrast they are examined at high resolution, if objects are large in size, they are examined at low resolution but the wavelet transforms are very useful when both the low and high resolution images exist. In the Wiener filter, when blurring filter is singular it amplifies the noise. Thus we require a denoising step which will remove the extra amplified noise. Thus there are two basic steps of this filter [12]:-

- inverse filtering
- Wavelet domain image den

The wavelet coefficients of an image are easily modelled with the help of a stochastic model. The wavelets [12] are basically little waves which are functions concentrated both in frequency and time. The wavelet transform appears to be the most appropriate method for non-stationary signals. The wavelet filter works in the following manner-

Step 1: Any clear image is read which is a collection of rows and columns of pixels

Step 2: The rows of the image are passed through a low pass filter to obtain the horizontal approximation of the image. And when the rows are passed through a high pass filter then horizontal details the image are obtained.

Step 3: Further if we pass the columns of the horizontal approximation through a low pass filter then an approximated image is obtained. And if we pass the columns through high pass filter then a vertical component is obtained.

Similarly, if we pass the columns of horizontal details of the image through a low pass filter then we obtain horizontal component. And if we pass the columns through a high pass filter then we obtain a diagonal component.

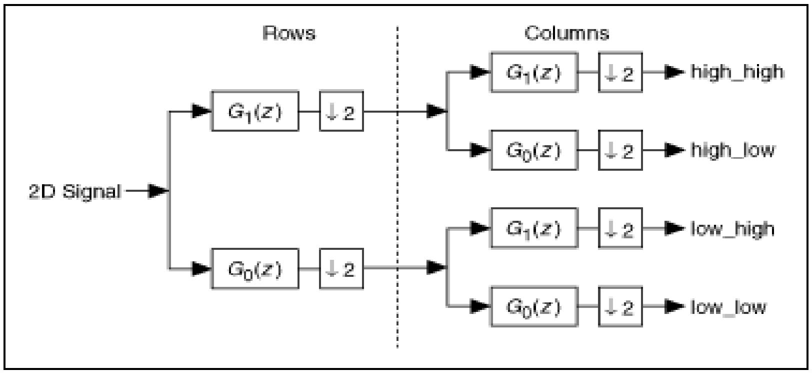

Figure 2: Division of operations on rows and columns to obtain four diagonals of wavelet transform

2. CURRENT WORK

Recently in [1], image restoration of motion blurred images have been analysed. Motion blur will be caused when there is any relative motion between the camera and the object to be captured. In some cases the camera is either in motion like if we want to capture picture of any object while sitting in a car. In other cases the object is in motion but camera is still like capturing the picture of any animal moving fast. The paper focused on image restoration images blurred by linear motion. The degradation model image restoration is similar to that of the basic image restoration model. In the blurred motion model of horizontal motion, two parameters are taken, x0 (t) and y0 (t) to represent how much motion has been done from actual coordinates in the blurred image. Wiener algorithm in fact gives better results but it may not be consistent with real images. So it will give better result only if the degradation system linear and the stationary model is satisfied by the real images. In [4] and [13], general method to restore the degraded images using wiener inverse filtering technique is been discussed. Their main objective was to minimize the mean square error between the original and the corrupted image. Other methods of restoration have also been proposed in [3], [5] and [6]. In [5], technique was proposed to restore the blur due to motion images using CMOS image sensors. In [6], the approach for restoring the images was through first segmenting the original and the noisy image into pieces. Then for the blurred portions only, restoration was performed and PSNR values were calculated. Then finally the parts were combined by clustering having the nearest PSNR values known by a method called Fuzzy clustering. Another approach in [3] of restoring the image was through an EM algorithm or Expectation Maximization algorithm which mainly focused on the deconvolution process of image restoration. It was mainly developed to solve the problem of real time images not concentrated into a single, stationary space. In [14] and [15], Richardson Lucy algorithm and Wiener algorithm are pondered upon. In [14], a comparison is made between the Lucy algorithm, a non-blind deconvolution technique where PSF is already known and the classic Wiener algorithm out of which Lucy was time consuming. An interesting approach of fusion was suggested in [15] where a noisy image was first individually restored by Lucy and Wiener algorithm and later on their results of restored image were fused together to get a more finer version of the restored image. A PDE-based image restoration model is proposed in [2] which restore the noisy images by using two PDE-variational methods, noise reduction and image reconstruction. Denoising minimizes the energy function based on novel regularizer function whose reconstructed image outperforms many restoration methods. Satellite images are often corrupted by aliasing, blur and noise. They can be a threat to interpretation since it is very difficult to reconstruct them. In [7] a method is defined where the large images when degraded can be restored back by divide and conquer strategy. The algorithm first divides the whole image into patches, then each degraded patch is reconstructed back to forms of original patches. Finally stitching and averaging results of patches is done to restore the entire satellite image.

3. PROPOSED WORK

The paper will analyse two classic algorithms of image restoration namely Wiener and Wavelet filters and will compare the results on the basis of the parameter SNR (signal to noise ratio). Modifying a bit in the implementation of Wiener filter algorithm will improvise it to obtain better SNR values than the original wiener and wavelet algorithm, however basic method of restoration is similar like the original wiener algorithm. Steps to be executed are-

Step1: Read any clear image.

Step2: For the image to pass through a degradation function, a parameter, sigma (σ) will be taken to form a noise whose equation will be formulated as-

$\sigma = 0.18 * (\text{maximum value of column-minimum value of column})$

Then noise will be calculated as convolution of sigma and original image as-

$\text{Noise} = \sigma * \text{original image}$

Step3: To this noise, original image will be added to form the noisy image. The modification will be done on calculating the σ value only which is not present in the original Wiener algorithm so that better results can be obtained than the Wavelet algorithm.

Step4: Then restoration process of wiener algorithm will execute by two methods- first, noise removal and then deconvolution method to restore back the more likely form of the restored image.

Step5: SNR values for original image and noisy image will be calculated by passing through a SNR function executed as follows-

1. Mean of original image's pixels is calculated.
2. Difference of each original image's pixel and mean in a temporary variable, tmp is stored.
3. Variational original image is calculated by sum of squares of all tmp variables of all pixels.
4. Similarly variational noise can be calculated in the same manner as the variational original image.
5. SNR will be calculated as the ratio of variational original image to variational noise by following condition-
6. If variational noise=0 then SNR=999.99
7. Else SNR = (variational original / variational noise)

The results of this modified Wiener algorithm will be compared with that of the Wavelet image restoration algorithm. A sample output of a noisy image and its restored results using wavelet thresholds and original wiener algorithm is been illustrated here. As we can see, the values of the SNR for each restored image can be plotted in the graph below. From recent findings, it has been proved that Wiener algorithm acts as a better approach providing better results than that of the wavelet with highest SNR. For my research also, there will be results in the following manner only and the modified Wiener algorithm proposed will yield even higher SNR value than the original Wiener algorithm. The tool used will be MATLAB and the comparison will be based on the parameter, SNR(signal to noise ration). For illustration, graphs will be plotted with several images in the X-axis and SNR values of modified Wiener and Wavelet algorithm in the Y-axis.

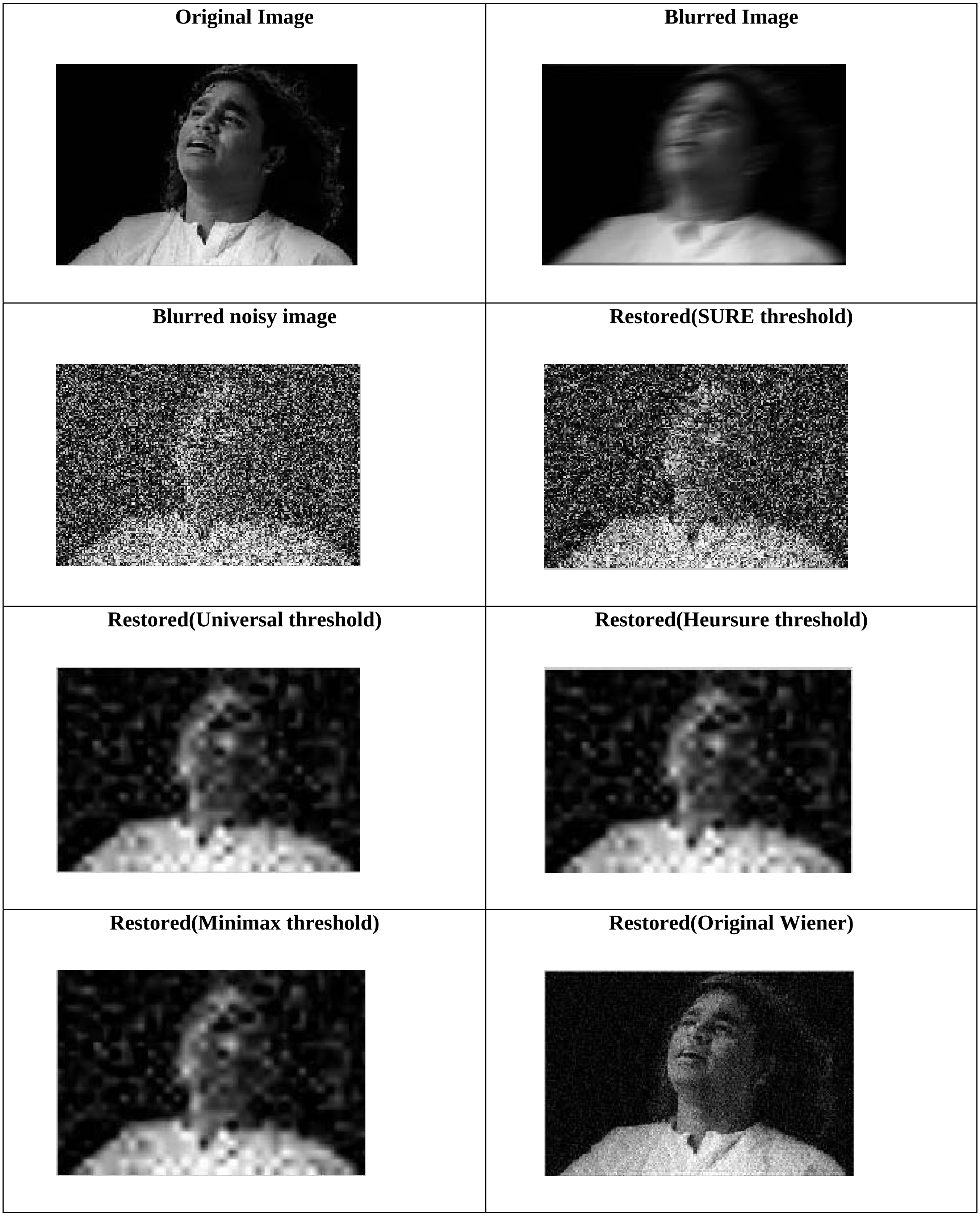

Figure 3: Sample results of restoration using original wiener and wavelet algorithm

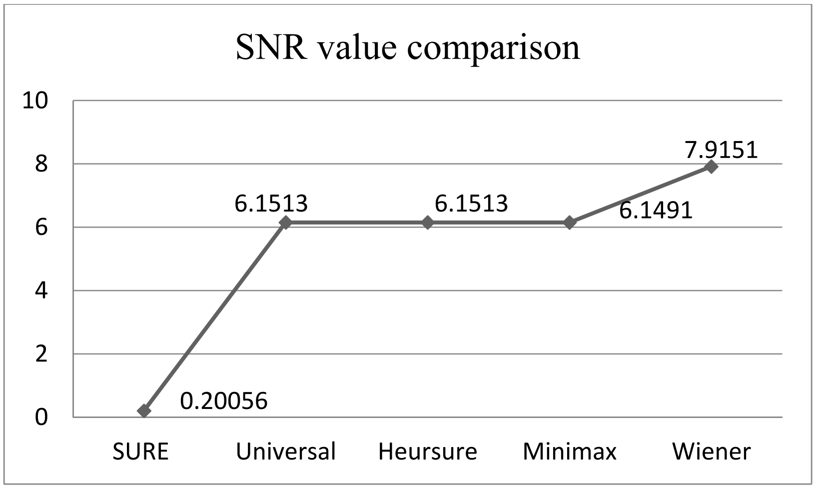

Figure 4: Graph showing Wiener algorithm yielding better result compared to Wavelet algorithm

4. CONCLUSION

With view of restoring any image, filters play a very important role and it is highly sensitive to any kind of noise elements present in the image. Thus a slight change in implementation of any filter can improve the results to a significant extent. Taking this view the Wiener algorithm is been a little modified to work upon real images to obtain better and optimised output than its original algorithm and is also compared to Wavelet algorithm. For this, it becomes relatively important to obtain as much as high SNR. Thus yielding a better SNR will prove that the particular filter can better restore the image compared to other two. In this way, the noisy images which are produced as a result of interference and noise during transmission can be restored back to its less likely form of original image so as to provide a better insight into the interpretation of images relative to subject concerned.

References

[1] Baochen Jiang, Aiping Yang, Chengyou Wang, Zhengxin Hou, "Comparison of Motion- blurred image restoration using Wiener Filter and Spatial Difference Technique," International Journal of Signal Processing, Image Processing and Pattern Recognition, Vol.7, No.2, pp.11-22, 2014.

[2] Tudor Barbu, Adrian Ciobanu, Mihaela Luca , "PDE-based Image Restoration using Variational Denoising and Inpainting Models,"Institute of Computer Science, Romania Academy Iasi, Romania, 2014.

[3] Mario A.T Figueiredo, Robert D. Nowak, "An EM Algorithm for Wavelet-based Image Restoration," IEEE Transactions on Image Processing, Vol. 12, No.8, August 2003.

[4] S.Jayaraman, S. Esakkirajan, T.Veerakumar, "Digital Image Processing," TMGH, New Delhi, 2009.

[5] Xinqiao Liu, Abbas El Gamal, "Simultaneous Image Formation and Motion Blur Restoration via Multiple Capture," Information Systems Laboratory, Department of Electrical Engineering Stanford University, Stanford CA 94305, 2000.

[6] Siddharth Saxena, Rajeev Kumar Singh, "A Novel Approach of Image Restoration Based on Segmentation And Fuzzy Clustering," International Journal of Signal Processing , Image Processing and Pattern Recognition, Vol.7, No.4, pp.255-264,2014.

[7] Yanfei He, Shunfeng Wang, "Adaptive Reciprocal Cell based Sparse Representation for Satellite Image Restoration," Advanced Science and Technology Letters, Vol.49 (SoftTech 2014), pp.281-28, 2014.

[8] Yi Bing Li, Qiang Fu, Fang Ye, Qi-di Wu, "Blind Image Restoration via The Integration of Stochastic and Deterministic Methods," Hindawi Publishing Corporation, Mathematical Problems in Engineering, Vol. 2014, Article ID 905189, 2014.

[9] Jing Xu, Xue- Cheng Tai, Li Lian Wang, "A two level Domain Decomposition Method for Image Restoration," Manuscript submitted to AIMS' Journals, Vol.X, No. 0X, XX 200X, pp. X-XX, 2010.

[10] Rinku Kalotra, Sh. Anil Sagar, "A Review: A Novel Algorithm for Blurred Image Restoration in the field of Medical Imaging," International Journal of Advanced Research in Computer and Communication Engineering, Vol.3, Issue 6, June 2014.

[11] M.R Banham, A.I Karsaggelos, "Digital Image Restoration," Vol.8, No.3, 2006.

[12] P.Premaratne, I.Burnett, "Role of Wavelet Transforms in Image Restoration," IEEE, DIO, Vol.9, No.3,2008.

[13] Anamika Maurya, Rajinder Tiwari, "A Novel Method of Image Restoration by using Different Types of Filtering Techniques," International Journal of Engineering and Innovative Technology (IJESIT), Vol.3, Issue 4, July 2014

[14] Madri Thakur, Shilpa Datar, "Image Restoration Based On Deconvolution by Richardson Lucy Algorithm," International Journal of Engineering Trends and Technology (IJETT), Vol.14, No.4, August 2014.

[15] Mohini Sharma, Shilpa Datar, "Image Restoration Using Wavelet based Image Fusion," International Journal of Engineering Trends and Technology (IJETT), Vol.15, No.1, September 2014.

[16] R.C Gonzalez, R.E Woods, Digital Image Processing. Addison-Wesley Publishing Company: Inc. 1992.