COMPARATIVE STUDY OF IMAGE RESTORATION TECHNIQUE USING ADAPTIVE, MEDIAN AND LUCY-RICHARDSON FILTERING

Anita Yadav[1], Anil Khatak[2]

Abstract: Image restoration is an art to improve the quality of image via estimating the amount of noises and blur involved in the image. With the passage of time, image gets degraded due to different atmospheric and environmental conditions, so it is required to restore the original image using different image processing algorithms. In this paper, different filtering techniques are used to restore the image. Input image is first converted to grayscale image then noise is inserted into it. Further brightness and contrast is applied and then restoration of the image is done using adaptive filter, median filter and lucy-richardson filter. MATLAB tool is used for restoration process. Experimental results are shown to compare the results of adaptive, median and lucy-richardson filter.

Keywords: Image restoration, noise, blur, image processing, grayscale image, adaptive filter, median filter, lucy-richardson filter.

I. INTRODUCTION

Image restoration is the process of recovering an image that has been degraded by using a priori knowledge of the degradation phenomenon. Restoration techniques involve modeling of the degradation function and applying the inverse process to recover the original image. This process is processed in two domains: spatial domain and frequency domain.Due to imperfections in the image formation process and the imaging device, the observed image often represents the degraded version of the original image. The corrections of these imperfections are mandatory in many of the subsequent image processing and vision tasks. Different types of degradations exist in the nature which includes noise, blur, geometrical degradations, illuminations etc. In this thesis, an effort has been made on removing the blur and noise from degraded images. Due to enormous applications of image restoration, researchers have gained interest to work in this area. The research on image restoration started in 1950s with astronomical imaging when scientists of United States of America and Soviet Union were involved in producing images of the Earth and the solar system. The images were degraded versions of the original images due to substandard imaging environment, spinning and the tumbling of the space craft. To retrieve the meaningful information from the degraded images, image restoration techniques were used. It is not a surprise to see that digital image restoration is used in astronomical imaging even today. Ground based imaging systems were also subject to blurring due to change in refractive index of the atmosphere [9]. Image restoration also plays an important role in medical imaging. It has been used to remove film-grain noise in X-ray images, angiography images and additive noise in magnetic resonance images [10–14]. It has applications to quantitative auto radiography (QAR) in which image is obtained by exposing X-ray film to a radioactive specimen. Though image restoration has been successfully applied, but still has a scope for improvement in quality and resolution. Image restoration has also received attention in media where old movies and picture are corrected in order to obtain a good quality picture which includes removal of scratches from the deteriorated films. Another important application of image restoration is in the field of image and video coding. The techniques used to increase the coding efficiency and to reduce the bit rates of the coded images create blocking artifacts. Image restoration has been successfully used as a post processing step after decompression to eliminate the blocking artifact resulted due to coarse quantisation of transformed coefficients [15–19]. In addition, digital image restoration is used in many other applications. Printing applications use restoration techniques to ensure high-quality halftone reproductions of continuous image [20]. Defense applications may also require restoration such as a guided missile which takes distorted images due to the pressure difference around a camera mounted on the missile. Looking at its wide-spread application areas in almost every field, it finds an important place in this technological world. Thus, even though several suggestions have been made, the field of image restoration still remains an active field of research.

II. IMAGE DEGRADATION MODEL

The degraded image $g(x, y)$ is obtained by applying the degradation operator H onto the image $f(x, y)$ along with the additive noise $\eta(x, y)$. The degradationphenomenon is mathematically expressed as,

$$g(x, y) = H[f(x, y)] + \eta(x, y) \qquad (2.1)$$

The objective of image restoration is to estimate $f(x, y)$ from the observed image $g(x, y)$ using the known value of H [7,8]. The overall degradation and restoration model is shown in the Figure 1.2. The operator H may be linear or nonlinear.

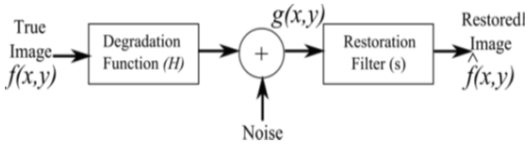

Figure1.2: Image degradation restoration model

IMAGE DEGRADATION AND RESTORATION PROCESS

The basic unit of a image is called a pixel or image element i.e. the image is divided into very small blocks called pixels. An image can be defined as a two dimensional function

$$I = f(x,y) \qquad (2.2)$$

where x and y are spatial coordinates. (x,y) represents a pixel. I is the intensity or grey level value which is the amplitude of f at any point (x,y). If the values of the coordinates (spatial coordinates) and the amplitude are finite and discrete, then it is called digital image. The degraded image g(x,y) can be represented as

$$g(x,y) = h(x,y) * f(x,y) + \eta(x,y) \qquad (2.3)$$

where $h(x,y)$ is the degradation function, $f(x,y)$ is the original image, the symbol * indicates convolution and $\eta(x,y)$ is the additive noise.

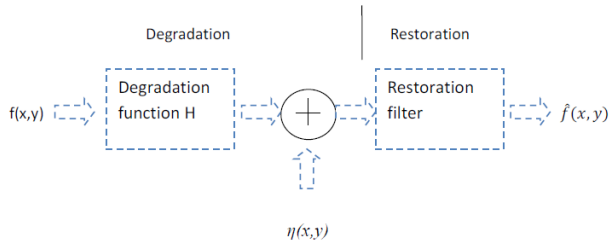

Figure 2.2 A Model of image degradation and restoration process

III. PROBLEM FORMULATION

3.1 Objectives

- To carry out extensive literature survey related to the Image restoration.
- To exhaustively compare and evaluate the performance of the existing techniques related to image restoration.
- To evaluate the performance of these technique by using MATLAB.

3.2 Methodology

The methodology that will be adopted to carry out this research work is as follows:

- To develop a clear understanding of the relevant topics through an exhaustive literature survey.
- Critical evaluation of the already published research work.
- Proposing and investigating ideas and solutions for improved performance.
- To carry out the performance analysis of the investigated system using simulation tool.
- Develop a comparative study and propose an improved solution

3.2.1 Adaptive Filtering

Adaptive filter is a computational device that attempts to model the relationship between two signals in real time in an iterative manner. Adaptive filters are often realized either as a set of program instructions running on an arithmetical processing device such as a microprocessor or DSP chip, or as a set of logic operations implemented in a field-programmable gate array (FPGA) or in a semicustom or custom VLSI integrated circuit. An adaptive filter is one which can automatically design itself and can detect system variation in time.

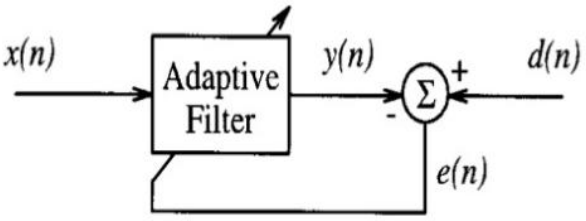

Figure 3.1 Adaptive Filtering

Here, x(n) is input digital signal
y(n) is output digital signal
d(n) is desired response
e(n) is error signal

3.2.2 Median Filtering

Median filtering is a nonlinear method used to remove noise from images. It is widely used as it is very effective at removing noise while preserving edges. It is particularly effective at removing 'salt and pepper' type noise. The median filter works by moving through the image pixel by pixel, replacing each value with the median value of neighboring pixels. The pattern of neighbors is called the "window", which slides, pixel by pixel over the entire image 2 pixels, over the entire image. The median is calculated by first sorting all the pixel values from the window into numerical order, and then replacing the pixel being considered with the middle (median) pixel value.

3.2.3 Lucy-Richardson Filtering

Another type of non-blind image restoration technique adopted in this study based on Lucy-Richardson method which possesses iterative procedure. This algorithm maximizes probability of restored image when convolved with PSF. If h_i is the observed value at pixel position 'i' then, it can be given as:

$$h_i = \sum d_{ir}\, a_r$$

where, d_{ir} is the PSF, the segment of light coming from true position 'r' that is observed at position 'i', a_r is the blurred image pixel value at position 'i'. Mathematical representation of the iterative process to calculate a_r is given as:

$$a_r^{(t+1)} = a_r^{(t)} \sum \frac{h_i}{b_i} d_{ir}$$

where, $d_{ir}$is PSF and $b_i = \sum r\, d_{ir}\, a_r$

Table 3.1 Comparison of adaptive, median and LR filtering

Technique	Advantage	Disadvantage
Adaptive Filtering	Adaptive filters can complete some signal processing tasks that traditional digital filters cannot Adaptive filters	Imprecise Removes information (not quantitative) Heavily affected by noise and

	can complete some real-time or online modeling tasks that traditional digital filters cannot.	imaging aberrations This technique can be extremely computer-intensive.
Median Filtering	No reduction in contrast across steps, since output values available consist only of those present in the neighborhood. Median filtering does not shift boundaries, as can happen with conventional smoothing filters. Since the median is less sensitive than the mean to extreme values (outliers), those extreme values are more effectively removed.	The disadvantage is that it is difficult to treat analytically the effect of a median filter. There is no error propagation. The median filter removes both the noise and the fine detail since it can't tell the difference between the two. The median filter can't distinguish fine detail from noise.
Lucy-Richardson Filtering	This filtering technique is simple and fast. Easy to implement. Implicit object size and positivity constraints	It does not work accurately with noise. Slow convergence in the absence of noise and instability in the presence of noise. Produces edge artifacts and spurious "sources"

IV. EXPERIMENTAL RESULTS

4.1 MATLAB

MATLAB stands for MATrixLABoratory. MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. MATLAB was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects, which together represent the state-of-the-art in software for matrix computation. Experimental results using MATLAB are shown here:

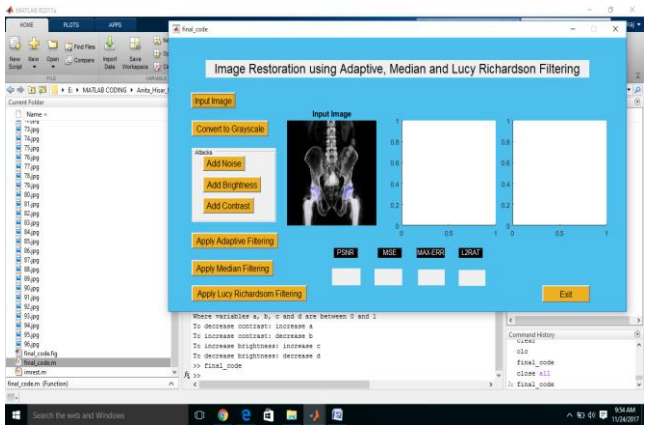

Figure 4.1 Input Image

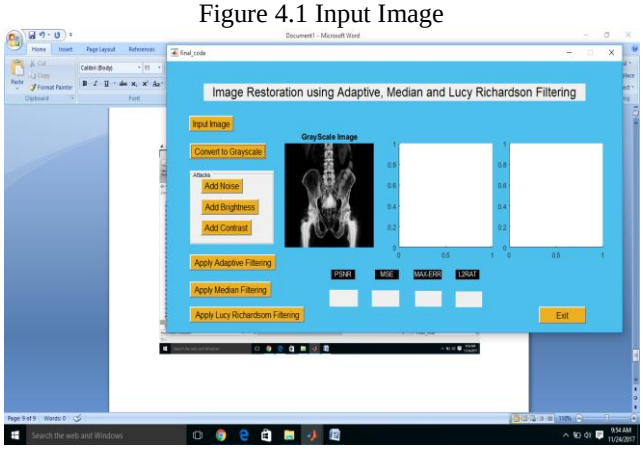

Figure 4.2 Grayscale Image

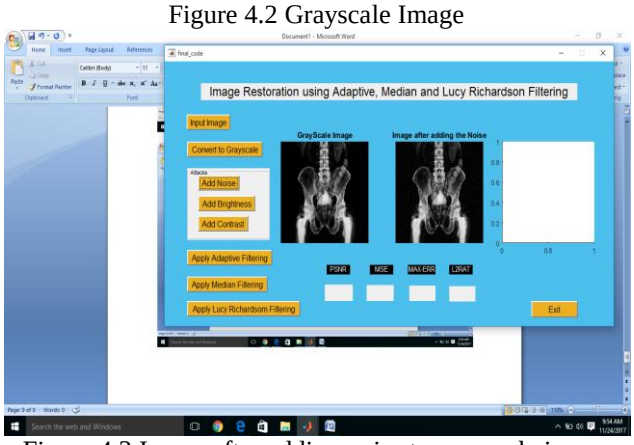

Figure 4.3 Image after adding noise to grayscale image

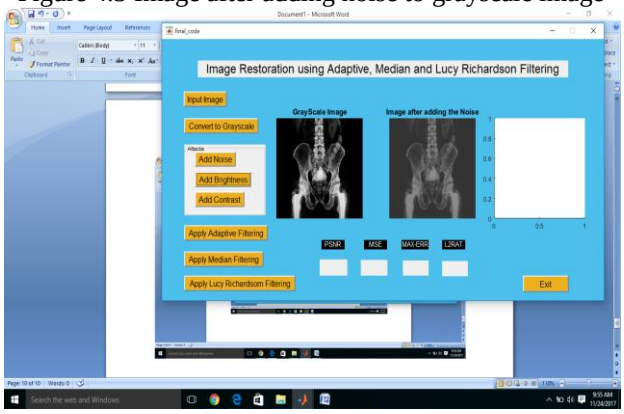

Figure 4.4 Image after adding brightness to noisy image

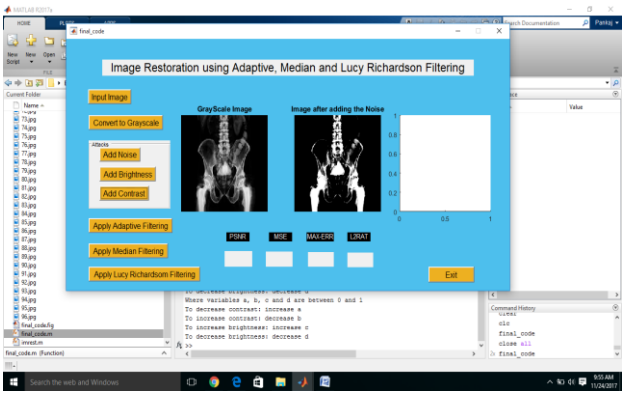

Figure 4.5 Image after adding contrast to noisy image

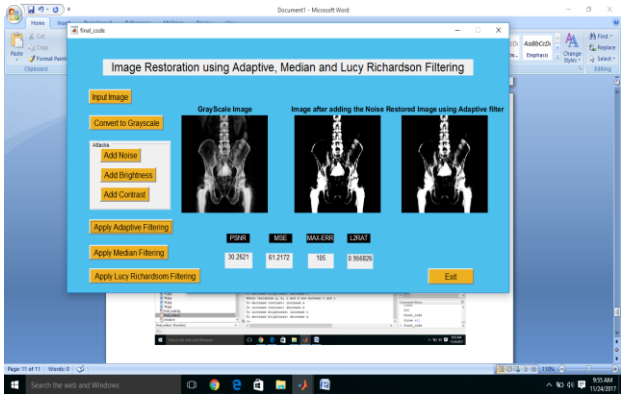

Figure 4.6 Restored Image using Adaptive Filter

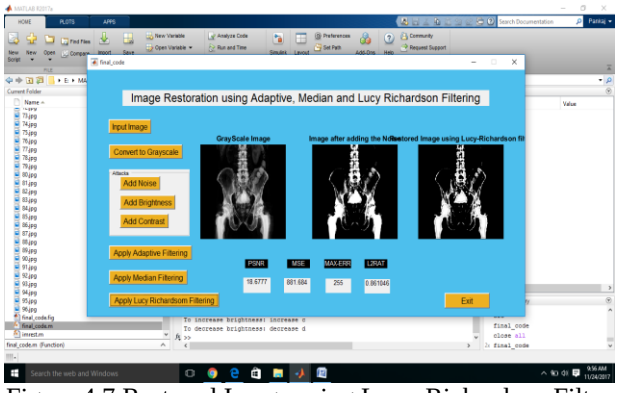

Figure 4.7 Restored Image using Lucy-Richardson Filter

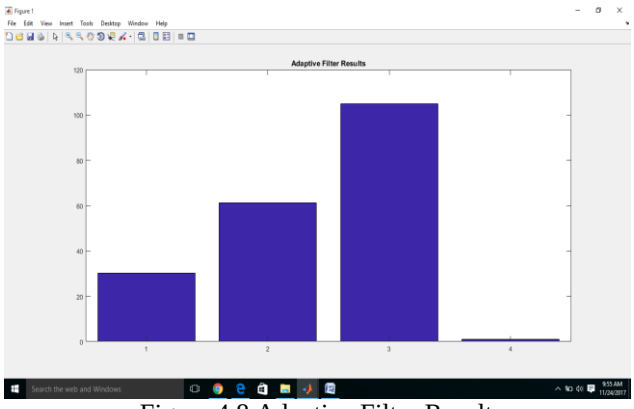

Figure 4.8 Adaptive Filter Result

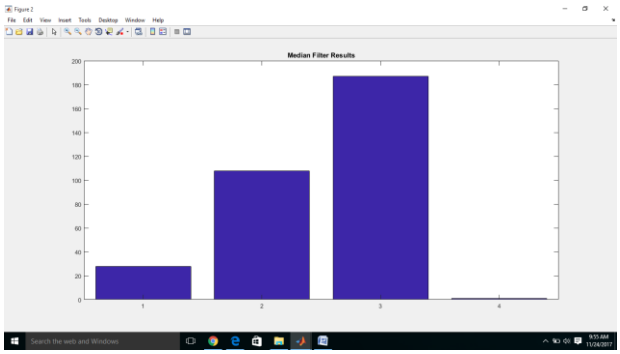

Figure 4.9 Median Filter Result

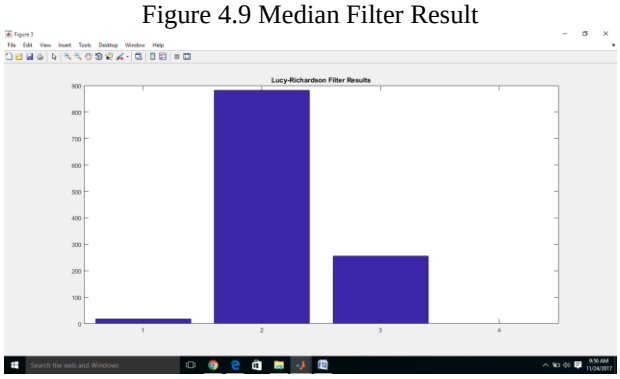

Figure 4.10 Lucy-Richardson Filter Result

V. CONCLUSION AND FUTURE SCOPE

5.1 Conclusion

Image restoration deems to reconstruct or recover a degraded image. The information loss due to image acquisition and transmission is restored under some constraints which are suitable for natural images and medical images. The lost information is recovered or restored with the prior information about natural images and medical images that leads to achieve more visual realism.This study presents adaptive filtering, median filtering and lucy-richardson filtering for image restoration to enhance the quality of an image. In this study input image is first converted to the grayscale image and then noise is inserted in it. Further, brightness and contrast is added to the noisy image and the restoration of image is done using adaptive filtering, median filtering and lucy-richardsonfiltering.In this paper,it is concluded that adaptive filtering is best one. MATLAB tool is used to perform filtering and simulation results show results using three different type of filtering.

5.2 Future Scope

In this paper, adaptive filtering, median filtering and lucy-richardson filtering is proposed to perform image restoration. In future, soft computing along with artificial intelligence techniques may be used to further enhance the quality of an image.

REFERENCES

[1] R. C. Gonzalez andR. E.Woods. Digital Image Processing. Addison Wesley, 2nd edition, 1992.
[2] Al Bovik. The Essential Guide to Image Processing. Academic Press, 2009.
[3] Jae S. Lim. Two-Dimensional Signal and Image

Processing. Prentice Hall,1990.

[4] R. Cucchiara, M. Piccardi, and A. Prati. Neighbor cache prefetching for multimedia image and video processing. IEEE Transactions on Multimedia, 6(4):539 – 552, August 2004.

[5] S. Iyer and S. V. Gogawale. Image enhancement and restoration techniques in digital image processing. Computer Society of India Communications, pages 6–14, June 1996.

[6] A. K. Jain. Fundamentals of Digital Image Processing. Prentice-Hall of India, 1989.

[7] Abd-KrimSeghouane. A note on image restoration using cp and mse. IEEE Signal Processing Letters, 15:61–64, July 2008.

[8] Abd-KrimSeghouane. Model selection criteria for image restoration. IEEE Transaction on Neural Networks, 20(8):13571363, August 2009.

[9] Mark R. Banham and Aggleos K. Katsaggelos. Digital Image Restoration. IEEE Signal Processing Magazine, 14(2):24 – 41, March 1997.

[10] C. L. Chan, A. K. Katsaggelos, and A. V. Sahakian. Image sequence filtering in quantum-limited noise with applications to low-dose fluoroscopy. IEEE Transactions on Medical Imaging, 12(3):610 –621, sep 1993.

[11] Y-S Han, D. M. Herrington, and W. E. Snyder. Quantitative angiography using mean field annealing. In Proceedings of Computers in Cardiology, pages 119–122, 1992.

[12] C. Charalambous, F. K. Ghaddar, and K. Kouris. Two iterative image restoration algorithms with applications to nuclear medicine. IEEE Transactions on Medical Imaging, 11:2–8, March 1992.

[13] V. A. Oliveira and J. M. Nightingale. Maximum image restoration in nuclear medicine. IEE Proceedings on Communications, Speech and Vision, 137(3):163 –169, june 1990.

[14] Hamid Soltanian-Zadeh, Joe P. Windham, and Andrew E. Yagle. A Multidimensional Nonlinear Edge-Preserving Filter for Magnetic Resonance Image Restoration. IEEE Transactions on Image Processing, 4(2):147–161, February 1995.

[15] Xiaobing Lee, Ya-Qin Zhang, and A.Leon-Garcia. Information loss recovery for block-based image coding techniques-a fuzzy logic approach. IEEE Transactions on Image Processing, 4(3):259 –273, mar 1995.

[16] T. P. O. Rourke and R. L. Stevenson. Improved image decompression for reduced transform coding artifacts. IEEE Transactions on Circuits and Systems for Video Technology, 5(6):490 –499, dec 1995.

[17] T. Ozcelik, J. C. Brailean, and A. K. Katsaggelos. Image and video compression algorithms based on recovery techniques using mean field annealing. Proceedings of the IEEE, 83(2):304 –316, feb 1995.

[18] Yongyi Yang, N. P. Galatsanos, and A. K. Katsaggelos. Regularized reconstruction to reduce blocking artifacts of block discrete cosine transform compressed images. IEEE Transactions on Circuits and Systems for Video Technology, 3(6):421 –432, dec 1993.

[19] A. Zakhor. Iterative procedures for reduction of blocking effects in transform image coding. Circuits and Systems for Video Technology, IEEE Transactions on, 2(1):91 –95, mar 1992.

[20] S. Hein and A. Zakhor. Halftone to continuous-tone conversion of error-diffusion coded images. IEEE Transactions on Image Processing, 4(2):208 –216, feb 1995.

