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A NOVEL TECHNIQUES OF IMAGE RESTORATION

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ABSTRACT

Image restoration is the process of reconstruction or recovering an image that has been corrupted by some degradation phenomenon. Degradation may occur due to motion blur, Gaussian blur, noise and camera mismatch. In order to improve the quality of the image so that the required objects can be easily accessible from the sensed images, the image restoration technique is used in the image processing. It improves the objectivity of the image and removes the noise and blurry content in the image. In this paper corrupted image have been recovered using Modified Lucy Richardson algorithm in the presence of Gaussian, Speckle and salt & paper noise with motion blur. The performance of this algorithm has been compared with Wiener filter, Regulized Filter, Lucy-Richardson Algorithm. The performance comparison done on the based on Mean Square Error (MSE), peak signal-to-noise ratio (PSNR), Structural Similarity (SSIM).The result shows that Modified Lucy Richardson method is better than Wiener filter, Regulized Filter, Lucy-Richardson Algorithm.

Keywords: *Image Restoration, Winner filter, Regulized filter, Lucy-Richardson algorithm, Noise, Motion Blur.*

I. INTRODUCTION

Image processing is any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or, a set of characteristics or parameters related to the image. An image may be defined as a two-dimensional function, f (x, y), where x and y are spatial (plane) coordinates, and the amplitude of f at any pair of coordinates (x, y) is called the intensity or gray level of the image at that point. When x, y and the amplitude values of f are all finite, discrete quantities, we call the image a digital image [1]. Note that a digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are referred to as picture elements, image elements and pixels. Pixel is the term most widely used to denote the elements of a digital image. Digital image processing refers to processing digital images by means of digital computers.

The field of image processing has grown considerably during the past decade with the increased utilization of imagery in numerous applications coupled with improvements in the size, speed, and cost effectiveness of digital computers and related signal processing technologies. Image processing has found a significant role in scientific, industrial, space, and government applications. The 1980s have been a decade of significant growth and maturity in this field. Digital image processing has become a recognized field of science, as well as a broadly accepted methodology, to solve practical problems in many different kinds of human activities. The applications involve a huge range, starting perhaps with astronomy, geology, and physics, medical, biological, and ecological imaging and technological exploitation. The results obtained in the area of digital image acquisition, synthesis, processing, and analysis are impressive.

II. IMAGE RESTORATION

Image Restoration is the process of obtaining the original image from the degraded image by using some prior knowledge of degradation phenomenon .Image restoration can be used in many different applications such as Scientific areas, Medical applications, Astronomy, Remote Sensing, Forensic Studies, Restoration of Compressed Images, Material Science, Military, Film industry etc. Image Restoration is the operation of taking a corrupted/noisy image and estimating the clean original image. It helps to eliminate and correct errors that do not accurately reflect the original images. It uses digital filtering i.e., used to eliminate dots or image spots. Image Restoration deals with improving the appearance of an image.

In spatial domain methods, the technique operates directly on the pixels of an image. The spatial domain methods are used for removing additive noise only. The degradation/restoration process can be described as:

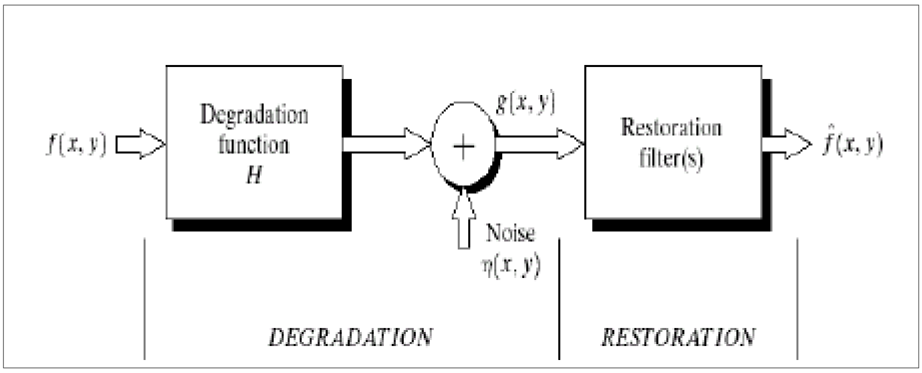

Figure - 1. Shows the degradation/restoration model

This Fig2 shows the original image f(x, y). The noise n(x, y) operates on input image and a degraded image g(x, y) is produced. The main aim of restoration process is to remove the degradation from the image and obtain the twin image f (x, y) of the original image. We want the output to be as same as possible to the original image. The Mathematical equation of Fig.2 is represented as follows, where h(x, y) is the function that causes distortion and n(x, y) is the noise. The symbol * represents convolution

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

In the spatial space, we are intrigued by the parameters that characterize the spatial qualities of noise, and whether the noise is related with the picture/image.

III. CATEGORIES OF IMAGE RESTORATION TECHNIQUES

Image Restoration Techniques are divided into two categories on the basis of knowledge about Point Spread Function (PSF). Point spread function (PSF) is the degree to which an optical system blurs (spreads) a point of light [8].

i. Blind Image Restoration:

This Technique allows the reconstruction of original images from degraded images even when we have very little or no knowledge about PSF. Blind Image Deconvolution (BID) is an algorithm of this type. Example- Lucy Richardson Algorithm

ii. Non-Blind Restoration:

This Technique helps in the reconstruction of original images from degraded images when we know that how image was degraded i.e. we have knowledge about PSF.

In this paper we only used the Known PSF convolution technique. Using PSF we restore the image from noise like Gaussian, Salt and Paper, and Speckle.

IV. PROPOSED WORK

Images are produced to record or display useful information. Due to imperfections in the imaging and capturing process, however, the recorded image invariably represents a degraded version of the original scene. The undoing of these imperfections is crucial to many of the subsequent image processing tasks. There exists a wide range of different degradations that need to be taken into account, covering for instance noise, geometrical degradations (pincushion distortion), illumination and color imperfections (under/over-exposure, saturation),and blur. The purpose of image restoration is to compensate for or undo these defects and improves the visibility of the image. The noise and blur models that are to be used in this paper are Speckle noise, Gaussian noise and Salt and Pepper noise with motion blur.

- **Speckle noise:** Speckle noise is a granular noise that inherently exists in and degrades the quality of the active radar and synthetic aperture radar (SAR) images. SAR is caused by unified processing of backscattered signals from multiple distributed targets [3]

- **Gaussian noise:** It represents statistical noise having probability density function (PDF) equal to that of the normal distribution, which is also known as the Gaussian distribution. In other words, the values that the noise can take on are Gaussian-distributed [3]. Principal sources of Gaussian noise in digital images arise during acquisition eg. Sensor noise caused by poor illumination and/or high temperature, and/or transmission eg. Electronic circuit noise.

- **Salt and Pepper noise:** Fat-tail distributed or "impulsive" noise is sometimes called salt-and pepper noise or spike noise. An image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions. This type of noise can be caused by analog-to-digital converter errors, bit errors in transmission [3].

- **Motion Blur:** motion blur is due to relative motion between the recording device and the scene. This can be in the form of a translation, a rotation, a sudden change of scale, or some combinations of these. The Motion Blur effect is a filter that makes the image appear to be moving by adding blur in a specific direction [3].

In this paper the Following techniques are used to restore a noisy and blur images.

1. **Image Restoration Using Regularized Filter:**

Regularized filtering is used in a better way when constraints like smoothness are applied on the recovered image and very less information is known about the additive noise. The blurred and noisy image is regained by a constrained least square restoration algorithm that uses a regularized filter. Regularized restoration provides almost similar results as the wiener filtering but viewpoint of both the filtering techniques are different. In regularized filtering less previous information is required to apply restoration. The regularization filter is frequently chosen to be a discrete Laplacian. This filter can be understood as an approximation of a Weiner filter. It uses the **deconvreg** function to de-blur an image using a regularized filter. A regularized filter can be used effectively when limited information is known about the additive noise [3].

2. **Image Restoration Using Weiner Filter:**

Wiener filter's working principle is based on the least squares restoration problem. It is a method of restoring image in the presence of blur and noise. The Wiener filtering is optimal in terms of the mean square error. In other words, it minimizes the overall mean square error in the process of inverse filtering and noise smoothing [3]. The Wiener filtering is a linear estimation of the original image [1]. Wiener that incorporates both the degradation function and statistical characteristic of noise into the restoration function. Weiner Filtering is also a non-blind technique for reconstructing the degraded image in the presence of known PSF. It removes or reduces to some extent the additive noise and inverts the blurring simultaneously. It uses the **deconvwnr** function to de-blur an image using a winner filter. Wiener Deconvolution can be used effectively when the frequency characteristics of the image and additive noise are known, to at least some degree. In the absence of noise, the Weiner filter reduces to the ideal inverse filter [8].

3. **Image Restoration Using Lucy Richardson Method:**

Lucy Richardson algorithm is also known as Lucy Richardson De-convolution, it is an iterative procedure for recovering a latent image that has been blurred by a known Point Spread Function (PSF). Use the **deconvlucy** function to deblur an image using the accelerated Lucy-Richardson algorithm. This function can be effective when you know the PSF but know little about the additive noise in the image. Pixels in the observed image can be represented in terms of the point spread function and the latent image as [3].
It is an iterative procedure in which the pixels of the observed image are represented using the PSF and the latent image as follows:

$$d_i = \Sigma\, p_{ij}\, u_j \qquad [1]$$

In equation, di is the observed value at pixel position i, pij is the PSF, the fraction of light coming from true location j that is observed at position i, uj is the latent image pixel value at location j.

4. Image Restoration Using Modified Lucy Richardson Method:

In the modified LR Algorithm we also input noisy and blur image. It is an iterative procedure for recovering a latent image that has been blurred by a known Point Spread Function (PSF). We take 10 to 15 iteration for **deconvlucy with DAMPAR** function. We will get better output image then other restoration technique. Using this method we take better restore image.

- **Proposed Algorithm**

Step 1: Read Noisy Image.

Step 2: calculate MSE, PSNR, SNR, and SSIM.

Step 3: Apply convolution technique for Image restore.

For Regulized filter

Reg = (Image name, PSF, noise power);

For winner filter

Wnr = (Image name, PSF, noise_var/noise_mean);

For Lucy-Richardson

Lucy = (Image name, PSF, noise value);

For Modified Lucy-Richardson

Lucy = (Image name, PSF, noise value, DAMPAR);

Step 4: Calculate MSE, PSNR, SNR, and SSIM for new restore image.

Step 5: Comparison with old image.

Step 6: For new iteration go to step 2.

In this method we get best restore image then main LR algorithm. We calculate it with the MSE, PSNR, SNR, and SSIM.

It calculates with follow Equations.

Mean Square Error: Computed as the root **Mean Square Error (MSE)** of the corresponding pixels in reference and restored image.

$$MSE = \frac{1}{M * N} \sum_{i=1}^{M} \sum_{j=1}^{N} (x_{ij} - y_{ij})2$$

Peak Signal-to-Noise Ratio: PSNR analysis uses a standard mathematical model to measure an objective difference between two images. It estimates the quality of a reconstructed image with respect to an original image. The basic idea is to compute a single number that reflects the quality of the reconstructed image.

$$PSNR = \frac{10 log_{10} 255^2}{MSE}$$

Structural Similarity Image: The SSIM compares the brightness, contrast and structure between each pair of vectors, where the structural similarity index (SSIM) between two Images *x* and *y* is given by the following expression:

$$SSIM = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)}$$

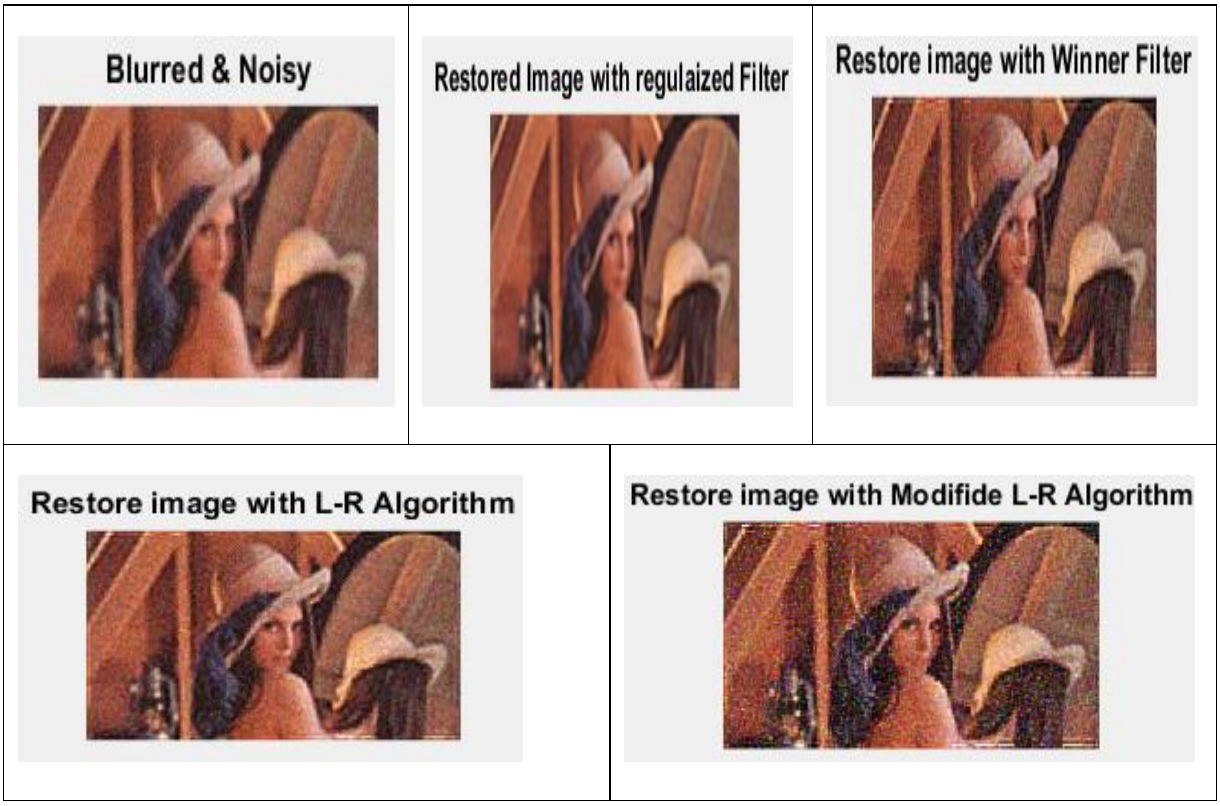

Figure - 2. Restore Image With Gaussian Noise.

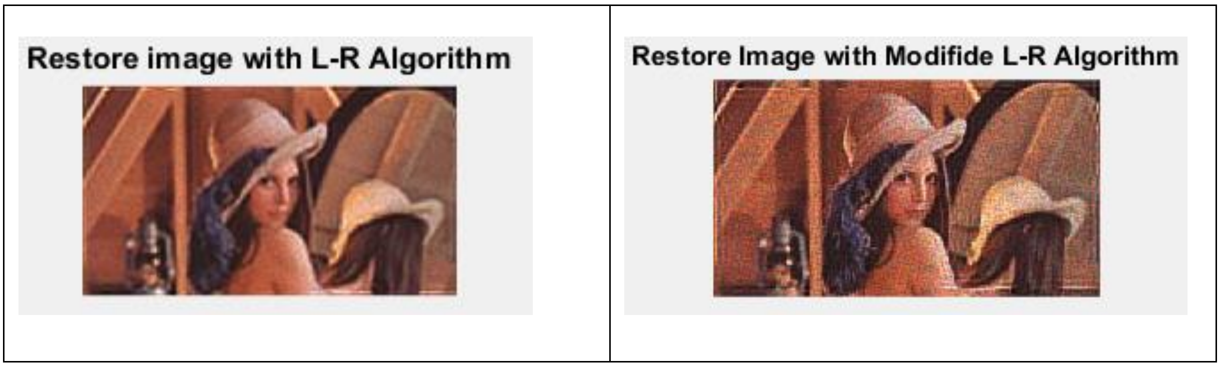

Figure - 3. Restore Image with Speckle Noise.

Figure - 4. Restore Image with Salt And Pepper Noise.

Here, we shows the different types of noisy image with their restoration technique.Fig-2 shows the Gaussian noise, Fig-3 shows the Speckle noise, and Fig-4 shows the Salt and Pepper noise. In the below table comparisons between Regulized filter, Winner filter, L-R algorithm with proposed Lucy-Richardson Algorithm.

For **Lenna** Image with Gaussian Noise calculate MSE, PSNR, SNR, and SSIM are below:

MSE=320.46 PSNR=23.073 SNR=15.610 SSIM=0.8300

Parameter	Regulized Filter	Winner Filter	L-R Algorithm	Proposed L-R Algorithm
MSE	189.558	591	321.82243	**723.238**
PSNR	25.35	22.284	23.0546	**19.538**
SNR	17.898	14.587	15.5924	**12.0757**
SSIM	**0.8990**	0.6089	0.8293	0.7091

Table 1: Performance evaluation metrics to evaluate image restoration with Gaussian noise for Lenna image.

For **Lenna** Image with Speckle Noise calculate MSE, PSNR, SNR, and SSIM are below:
MSE= 234.8215 PSNR= 24.4234SNR= 16.9611 SSIM= 0.8853

Parameter	Regulized Filter	Winner Filter	L-R Algorithm	Proposed L-R Algorithm
MSE	510.2772	420	165.35246	**606.98165**
PSNR	21.0527	23.7667	25.9467	**20.2990**
SNR	13.5905	16.3044	18.4844	**12.8368**
SSIM	0.8198	0.8985	**0.9151**	0.7749

Table 2: Performance evaluation metrics to evaluate image restoration with Speckle noise for Lenna image.

For **Lenna** Image with Salt and Pepper Noise calculate MSE, PSNR, SNR, and SSIM are below:

MSE= 232.9143 PSNR= 24.4588 SNR= 16.9966 SSIM= 0.8861

Parameter	Regulized Filter	Winner Filter	L-R Algorithm	Proposed L-R Algorithm
MSE	332.8101	332	187.22493	**489.1166**
PSNR	22.9088	24.7915	25.4072	**21.2367**
SNR	15.4466	17.3293	17.9449	**13.7744**
SSIM	0.8523	0.8957	**0.9050**	0.8261

Table 3: Performance evaluation metrics to evaluate image restoration with Salt and Pepper noise for Lenna image.

V. CONCLUSION

In this paper we shows the proposed L-R algorithm have better restoration result than any other method. The result shown that this algorithm better work for salt and pepper noise. In the fig-4 we show better clarity in restore image. For Gaussian noise and speckle noise it works but image have some blur in restore image. For SSIM it looks in different method. But MSE, PSNR and SNR are improved with proposed method. For future work we also improved it value with adding more function in algorithm. We also improved efficiency improved in proposed method. This work is done in MATLAB 2014b (8.4.0).

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