Abstract- Image restoration is a field of image processing which deals with restoring an image that has been degraded by some degradation phenomenon. Degradation may occur due to motion blur, Gaussian blur, noise or camera mismatch. This paper presents a novel approach of image restoration based on image fusion. In this work a motion blurred and noisy image is first restored using Wiener and Lucy Richardson method. Wavelet based Image fusion technique is then applied for restoration. It is observed that image fusion technique provides better results as compared to previous two techniques. Performance of all the methods has been compared on the basis of performance parameters MSE and PSNR.

Keywords- Image restoration, Image fusion, Wavelet, MSE, PSNR, Wiener, Lucy Richardson.

I. INTRODUCTION
Restoration of digital images from their degraded model has always been a problem of interest. A perfect solution to the problem of image restoration is generally determined by nature of degradation phenomena so it is highly dependent on the nature of the noise present there.

A. Motion Blur
Blur can be caused by relative motion between the camera and the original scene, by an out of focus of optical system, atmospheric turbulences and aberrations in the optical system. Variety of noise introduce by medium also cause degradation and that results variation, distortion or shading in the original image. So before further image processing we have to remove the blur and reduce the amount of noise. Blur is a linear convolution of an image with a blurring kernel, also known as the PSF.

\[ g(x, y) = f(x, y) * h(x, y) + v(x, y) \]

In this equation, \( h(x, y) \) is the blurring function, that is convolved with the original image \( f(x, y) \) and \( v(x, y) \) is the noise function, noise is additive Gaussian in nature. In order to obtain the uncorrupted image, we need to find the blurring function \( h(x, y) \). \( g(x, y) \) is the restored image.

B. Wiener Filter
It is linear image restoration named after Norbert Wiener, who first proposed the method in 1942. It is also a non blind method in which \( h(x, y) \) is known to us. The method Considering image and noise as random processes and objective is to find an estimate \( \hat{f} \) the uncorrupted image \( f \) such that the mean square error between them should be minimized. This error is given by

\[ e^2 = E\{(f - \hat{f})^2\} \]

Where \( E \) is the expected value operator and \( f \) is the undegraded image. It not only performs the deconvolution by inverse filtering (high pass filter) but also removes the noise with a compression operation (low pass filter).

\[ \hat{f}(u, v) = \frac{1}{H(u, v)^2} \cdot \left[ |H(u, v)|^2 \cdot \left( \frac{S_n(u, v)}{|F(u, v)|^2} \right) + |S_h(u, v)| \right] \cdot g(u, v) \]

\( H(u, v) = \) the degradation function
\( |H(u, v)|^2 = H^*(u, v) \cdot H(u, v) \)
\( H^*(u, v) = \) the complex conjugate of \( H(u, v) \)
\( S_n(u, v) = |N(u, v)|^2 = \) the power spectrum of the noise
\( S(u, v) = |F(u, v)|^2 = \) the power spectrum of the undegraded image

C. Lucy Richardson Algorithm
The Lucy Richardson (LR) algorithm is an iterative nonlinear restoration method maximizing the likelihood function of the model yield an equation that is satisfied when following iteration converges-

\[ f_{k+1}(x, y) = f_k(x, y) \left( h(-x, -y) \cdot \frac{g(x, y)}{h(x, y)} \right) \]

For best results number of iteration depends on the size and complexity of the PSF matrix. Small PSF or few steps sometime cause very smooth image and increasing numbers of iteration slow down process but also produce ringing effect. Thus for the “good” quality of reconstructed image, the optimal no. of iterations are decided manually as per the PSF size.

II. PROPOSED METHOD
Restoration techniques are basically mathematical modelling of degradation and then applying inverse process to restore the original image. In proposed method we compare Wiener filter, Lucy richadson and wavelet based image fusion technique for image restoration for removal of motion blur. Images restored are compared on the basis of performance parameters like PSNR and MSE.
A. Image Restoration
Restoration is to reconstruct the original image with a priori knowledge of the degradation. Degraded image is added with noise and then given to restoration filter which suppress the noise and the output which we get is near to the original image. To remove blur Wiener and LR method is used as restoration filters. Wiener is good with less complexity but LR provides better PSNR than Wiener.

B. Block Diagram
Fig. 1 shows the block diagram of the proposed method, in first step noise is added with the original image. To remove motion blur, in second step image is restored using restoration algorithms that is Wiener (filter 1) and LR (filter 2). Finally both Images are fused using image fusion method to get the fused image in third step.

III. IMAGE FUSION
In image fusion the good information from each of the given images is fused together to form a resultant image whose quality is superior to the input source images. First DWT was performed on the source image then images are decomposed into four sub-bands LL, LH, HL, and HH. Then fused wavelet coefficient map can be constructed from the wavelet coefficients of the source images according to the fusion decision map. The decision map shows each value which is the index of source image, may be more informative on the corresponding wavelet coefficient. Then, we will actually make a decision on each coefficient. Mainly two type of fusion rule are used first pixel-based so only pixel values either max or average can consider and other is window-based so consider not only the corresponding coefficients, but also their close neighbours, say a 3x3 or 5x5 windows. We used pixel level maxima rule in this work. On the basis of this fusion decision map of source images, we can make the wavelet coefficient map for fused image and then obtain the fusion image by inverse wavelet transform.

IV. EXPERIMENTAL RESULTS
The effect of restoration methods compares by two performance parameter-

A. Mean Square Error (MSE) -
\[ \text{MSE} = \text{mean}((F(i,j) - R(i,j))^2) \]

B. Peak Signal to Noise Ratio (PSNR) -
\[ \text{PSNR} = 10 \times \log_{10} \left( \frac{1}{\text{MSE}} \right) \]

<table>
<thead>
<tr>
<th>Image size</th>
<th>Wiener filter (dB)</th>
<th>Lucy Richardson (dB)</th>
<th>Wavelet based image fusion (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>256x256</td>
<td>15.868</td>
<td>19.43</td>
<td>19.447</td>
</tr>
<tr>
<td>512x512</td>
<td>20.197</td>
<td>20.768</td>
<td>20.834</td>
</tr>
<tr>
<td>256x256</td>
<td>23.805</td>
<td>24.098</td>
<td>25.377</td>
</tr>
<tr>
<td>512x512</td>
<td>26.808</td>
<td>28.759</td>
<td>29.002</td>
</tr>
</tbody>
</table>
Table no.1 and Table no.2 shows all three methods of restoration and comparison of that for different image size and for variable variance in terms of PSNR (table no.1) and MSE (table no.2).

Table no.3 and Table no.4 provides PSNR and MSE of image fusion using different wavelets. DB4 gives best results compare to all wavelets.
This paper compares three methods of restoration for removal of motion blur. Blurred image is restored using Wiener filter method and Lucy Richardson method. The results based on Lucy Richardson provided better results than Wiener filter method. Then a third method of Wavelet based image fusion is used to achieve higher PSNR and minimum MSE as compared to other two techniques. For the further work the performance of this method can be compared with the other fusion algorithms like edge based fusion and region based fusion.

REFERENCES

5. “Estimation of motion blurs PSF from differently exposed Image frames.”