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Image Restoration Model with Wavelet Based Fusion

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Abstract
Image Restoration is a field of Image Processing which deals with recovering an original and sharp image from a degraded image using a mathematical degradation and restoration model.This study focuses on restoration of degraded images which have been blurred by known or unknown degradation function. On the basis of knowledge of degradation function image restoration techniques can be divided into two categories: blind and non-blind techniques.Three different image formats viz..jpg(Joint Photographic Experts Group),.png(Portable Network Graphics) and .tif(Tag Index Format) are considered for analyzing the various image restoration techniques like Deconvolution using Lucy Richardson Algorithm (DLR), Deconvolution using Weiner Filter (DWF), Deconvolution using Regularized Filter (DRF) and Blind Image Deconvolution Algorithm (BID).The analysis is done on the basis of various performance metrics like PSNR(Peak Signal to Noise Ratio), MSE(Mean Square Error) , RMSE(Root Mean Square Error).
Keywords— Lucy Richardson Algorithm, Weiner Filter, Regularized Filter, Blind Image Deconvolution, Gaussian Blur, Point Spread Function, PSNR, MSE, RMSE

I. INTRODUCTION

Image processing algorithms are basically developed to overcome different problems. Some of these include image restoration, image enhancement, image segmentation and the list goes on. In this paper, we review various image restoration methods. Image restoration is the task of minimizing the degradation in an image i.e. recovering an image which has been degraded due to presence of noise and the original scene is not clear. Image restoration assures good insights of image when it is subjected to further techniques of image processing. Due to certain imperfections in the imaging or capturing process, the captured image is a degraded version of the original scene. The imperfections in the images captured could be due to camera miss focus, motion blurs i.e. whenever there is a relative motion between camera and the scene being captured, the image captured is degraded [1]. The idea of restoration of such degraded images has become an important tool for many technological applications such as space imaging, medical imaging and many other post-processing techniques.

Image restoration techniques are methods which attempt the inversion of some degrading process. Image restoration technique can be broadly classified into two types depending upon the knowledge of degradation. If the prior knowledge about degradation is known then the deterministic method of image restoration can be applied. If it is not known then the stochastic method of image restoration has to be employed. Restoration often exhibits artefacts near the edges, as linear methods are unable to recover missing frequency components which lead to Gibbs effect

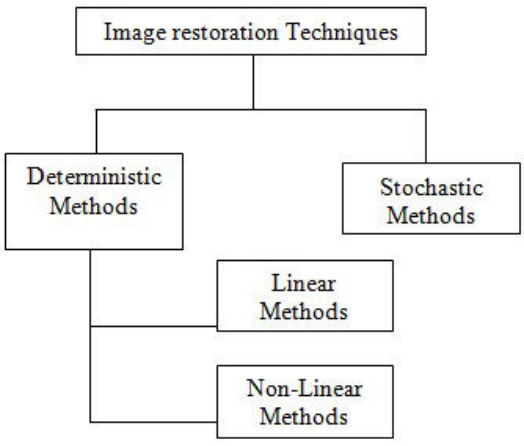

Fig 1. Classification of Image-restoration techniques

II. LITERATURE SURVEY

Digital images are corrupted by various kinds of noise during the process of acquisition and/or

transmission. The detection and removal of this noise plays a crucial role in restoration. Estimating the noise level from a single image seems like an impossible task, and due to this we need to recognize whether local image variations are dude to colour, texture, or lighting variations from the image itself or due to the noise. It might seem that accurate estimation of the noise level would require a very sophisticated prior model for images.

Image restoration is usually the first step of the whole image processing process. It increases the quality of the image by getting rid of noisy pixels. The restoration of an actually degraded image can be done by writing algorithms, which go on for identifying a noisy pixel in the entire image. The image restoration technique appears in many fields. These include- astronomy, military, medicines to name a few. Photo processing labs may also find restoration techniques a valuable tool in touching up special photographs. These fields have diverse aims for image restoration, but certain fundamentals are common to all image restoration problems. The degradations may have many causes, but the two types of degradations that are often dominant are noise and blurring, each of which introduces peculiar problems in image restoration.

Gupta *et.al* in Feb 2011 proposed a method to restore images affected by motion blur by using three stages. In the first stage a comparison of two image restoration methods was carried out, namely wiener filter and blind deconvolution. To improve the quality of image wavelet based image fusion was proposed in second stage. Finally in third stage the fused images are again restored using a low pass filter. The effectiveness of the methods was compared using parameters like RMSE and PSNR. The work showed that Wiener filter followed by Wavelet based Image Fusion provided the better results than iterative blind deconvolution method followed by Wavelet based Image Fusion**.**

Kaur *et.al* in 2012 proposed a novel approach for image restoration by removing the blur degradation by using blind and non-blind techniques.. In this approach the three different image formats viz..jpg(Joint Photographic Experts Group), .png(Portable Network Graphics) and .tif(Tag Index Format) are considered for analyzing the various

image restoration techniques like Deconvolution using Lucy Richardson Algorithm (DLR). Deconvolution using Weiner Filter (DWF), Deconvolution using Regularized Filter (DRF) and Blind Image Deconvolution Algorithm (BID).In this approach the analysis is done on the basis of various performance metrics like PSNR(Peak Signal to Noise Ratio), MSE(Mean Square Error) , RMSE(Root Mean Square Error).

Salem *et.al* in 2011 proposed a four types of techniques of deblurring image as Wiener filter, Regularized filter,Lucy Richardson deconvlution algorithm and Blind deconvlution algorithm with an information of the Point Spread Function (PSF) corrupted blurred image with Different values of Length and Theta and then corrupted by Gaussian noise for image restoration. The same method is applied to the remote sensing image and they are compared with one another. So as to choose the base technique for restored or deblurring image.In this method the study of restored Motion blurred image with no any information about the Point Spread Function (PSF) by using same four techniques after execute the guess of the PSF, the number of iterations and the weight threshold of it. To choose the base guesses for restored or deblurring image of this techniques.

Patel *et.al* in 2012 propose an approach for image restoration based on wavelet based image fusion. This approach utilizes Blind de-convolution, and Wiener filter methods, They adopts regularized iteration to restore the degraded image. This work proposes the implementation of Wiener filter with Image fusion to reduce the computational complexity with better acceptable restoration results of image restoration method.. The performance of the every stage is tabulated for the parameters like SNR and RMSE of the restored images .

Khare *et.al* in 2011 compared the performance of various for image restoration techniques like Richardson-Lucy algorithm, Wiener filter, Neural Network approach, on the basis of PSNR(Peak Signal to Noise Ratio). They are widely used for restoration of image in various fields of applications, such as medical imaging, astronomical imaging, remote sensing, microscopy imaging, photography deblurring, and forensic science, etc. Often the benefits of improving image quality to the maximum possible extent for outweigh the cost and complexity of the restoration algorithms involved.

A. Prochazka *et.al* in 2005 propose a method for image restoration based on Wavelet Transform. Wavelet transforms (WT) provide the alternative to the short-time Fourier transform (STFT) for non-stationary signal analysis. Information about signals resulting from a selected process can be based upon signal decomposition by a given set of wavelet functions into separate levels or scales resulting in the set of wavelet transform coefficients. These values can be used for signal compression, signal analysis, segmentation and in the case that these coefficients are not modified they allow the following perfect signal reconstruction. In the case that only selected levels of signal decomposition are used or wavelet transform coefficients are processed it is possible to extract signal components or to reject its undesirable parts. Using the threshold method it is further possible to reject noise and to enlarge signal to noise ratio. The de-noising algorithm assumes that the signal contains low frequency components and it is corrupted by the additive Gaussian white noise with its power much lower than power of the analyzed signal. The whole method consists of the following steps:

• Signal decomposition using a chosen wavelet function up to the selected level and evaluation of wavelet transform coefficients
• The choice of threshold limits for each decomposition level and modification of its coefficients.
• Signal reconstruction from modified wavelet transforms coefficients.

Results of this process depend upon the proper choice of wavelet functions, selection of threshold limits and their use.

Hiroko *et.al* in 2009 proposed a method for image restoration with the use of Weiner Filter in frequency domain [9]. This work has presented the wiener filter performance comparison in the presence of white noise in space domain and frequency domain for image restoration.

III. Basic Model of Image Restoration

The main objective of Image Restoration is to recover the original image from a degraded image which is blurred by a degradation function.The original image is first get degraded using degradation function, the noise is get added to this generated output after degradation function.

After receiving this degraded image, this degraded image is given to Restoration Filter, which suppress the noise, and produce the output which is more or less comparative to original image.

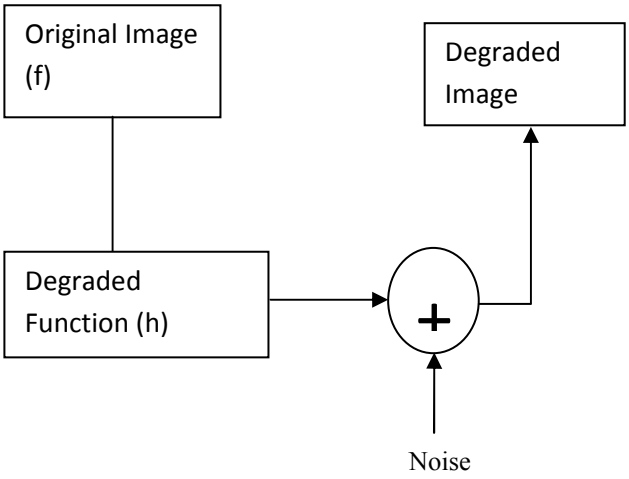

Fig 2. Image Degradation Model

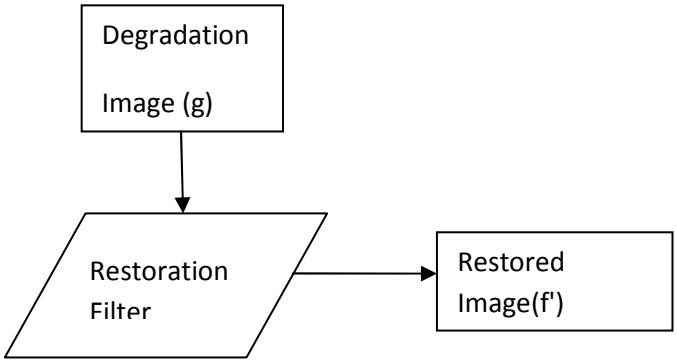

Fig 3. Image Restoration Model

Image Restoration Techniques are divided into two categories on the basis of knowledge about Point Spread Function (PSF):

1) 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.

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 a knowledge about PSF.

Deconvolution using Lucy Richardson Algorithm (DLR), Deconvolution using Weiner Filter (DWF), Deconvolution using Regularized Filter (DRF) are Non Blind Algorithms.

IV. IMAGE RESTORATION TECHNIQUES

Blind De-convolution Method:

De-convolution is a signal-processing operation that, ideally, unravels the effects of convolution performed by a linear time-invariant system operating on an input signal. In deconvolution, the output signal and the system are both known and the requirement is to reconstruct what the input signal must have been. In blind deconvolution, only the output. signal is known (both the system and the input signal are unknown), and the requirement is to find the input signal and the system itself. But it needs higher Computation So it is lengthy process for real time systems

Deconvolution using Wiener Filter

Weiner Filtering is also a non blind technique for reconstructing the degraded image in the presence of known PSF. It removes the additive noise and inverts the blurring simultaneously. It not only performs the deconvolution by inverse filtering (highpass filtering) but also removes the noise with a compression operation (lowpass filtering). It compares with an estimation of the desired noiseless image. The input to a wiener filter is a degraded image corrupted by additive noise. The output image is computed by means of a filter using the following expression [13]:

$$f^{\wedge} = g * (f + n) \qquad (1)$$

In equation (1), f is the original image, n is the noise, $f^{\wedge}$ is the estimated image and g is the wiener filters response.

Deconvolution using Lucy Richardson Algorithm

DLR is a non blind technique of image restoration, used to restore a degraded image that has been blurred by a known PSF. It is an iterative procedure in which the pixels of the observed image are represented using the PSF and the latent image as follows [14]:

$$d_i = \Sigma\, p_{ij}\, u_j \qquad (2)$$

In equation (2), d_i is the observed value at pixel position „i", p_{ij} is the PSF ,the fraction of light coming from true location „j" that is observed at position „i" , u_j is the latent image pixel value at location „j" . The main objective is to compute the most likely „u j " in the presence of observed d_i and known PSF p_{ij} as follows:

$$u_j^{(t+1)} = u_j^{(t)} \sum_i \frac{d_i}{c_i} p_{ij} \qquad (3)$$

$$c_i = \sum_j p_{ij}\, u_j^{(t)} \qquad (4)$$

Image Fusion

Extracting more information from multi source images is an attractive thing in remotely sensed image processing, which is recently called data fusion[6]. There are many image fusion methods so far, such as WS. PCA. WT. GLP etc. Among these methods WT and GLP methods can preserve more image spectral characters than others. So here we adopt –wavelet method (as it is proposed to improve the geometric resolution of the images).

Image fusion is the process of combining two or more source images into composite images with extended information content.

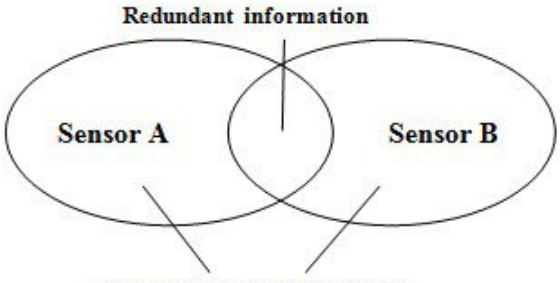

Fig 4. Image Fusion

Wavelet Based Image Fusion

Wavelet transform [5],[10], [12] is first performed on source images. Then a fusion decision map is generated

based on a set of fusion rules. Then fused wavelet coefficient map can be constructed from the wavelet coefficients of the source images according to the fusion decision map. Finally the fused image is obtained by performing the inverse wavelet transform.

The 2-dimensional discrete wavelet transform (DWT) [4] and the Laplacian image pyramid decompose an image into its multiscale edge representation. Based on the fact that the human visual system is primarily sensitive to local contrast changes, i.e. edges, the following fusion method can be developed:

In the first step a DWT decomposition is applied on all input images, resulting in a multiscale edge representation of the input imagery. Then a composite multiscale edge representation is built by a selection of the most salient wavelet coefficients of the input imagery. The selection scheme can be a simple choose-max of the absolute values or a more sophisticated area based energy computation [2], [3].

In the final step, the fused image is computed by an application of the inverse DWT on the composite wavelet representation. It is well known that the DWT yields a shift variant signal representation resulting in a shift dependent fusion scheme.

V. PERFORMANCE MEASURES

1. **Mean Square Error**:

$$MSE = \frac{1}{MN}\sum_{Y=1}^{M}\sum_{X=1}^{N}[I(x,y) - I^{'}(x,y)]^2$$

Where I(x,y) is the original image, I'(x,y) is the approximated version (which is actually the decompressed image) and M,N are the dimensions of the images.

2. **Signal to Noise Ratio: Signal-to-noise ratio** (often abbreviated **SNR** or **S/N**) is a measure used in science and engineering that compares the level of a desired signal to the level of background noise. It is defined as the ratio of signal power to the noise power. A ratio higher than 1:1 indicates more signal than noise. The signal to noise ratio (SNR) is a well known measure which is defined as follows:

$$SNR_{db} = 10\log_{10}\left(\frac{Asignal}{Anoise}\right)^2 = 20\log_{10}\left(\frac{Asignal}{Anoise}\right)$$

VI. RESULTS

Comparison based on MSE

S. No.	Image Size	Noisy Image	Blind Decon	Lucy Richar	Wiener Filter	Wavelet based
1	64x64	32.28	37.84	11.84	17.12	14.42
2	128x128	28.49	31.88	11.84	16.66	15.56
3	256x256	18.76	20.06	11.84	13.93	14.23

Comparison based on SNR

S. No.	Image Size	Noisy Image	Blind Decon	Lucy Richar	Wiener Filter	Wavelet based
1	64x64	20.66	19.07	27.86	27.00	41.16
2	128x128	21.91	20.07	26.21	27.26	33.72
3	256x256	26.09	25.42	27.56	29.07	30.95

VII. CONCLUSION

This paper proposed a scheme for Image restoration using Wavelet based image fusion with considering white Gaussian noise with motion blur. The work will be carried out on MATLAB image processing tool box.

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