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An efficient blind deconvolution algorithm for image resolution enhancement

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Abstract:

Image restoration is one of the important implementations in image processing. It deals with the recovery of an original image from a degraded image using the mathematical model of degradation and restoration for image. It is very important in many applications like medical, satellite and photography. Even though there are various existing techniques are available, there is always a need for more efficient methods. This paper deals with a combination of blind and non blind deconvolution techniques in order to improve the quality of the restored image. The image can be blurred by adding different types of noise to the image. Different filters and techniques are implemented in removing each type of noise and their performance are evaluated based on the metrics like PSNR, MSE and RMSE.

Key words: Image restoration, blind and non blind deconvolution.

Introduction:

Image restoration is an operation of taking a corrupt or noisy image and estimating the clean, original image. The objective of image restoration is to reduce noise and recover resolution loss. The most straight forward and a conventional technique for image restoration is to use deconvolution which is performed in frequency domain. In an image, corruption may come in many forms such as motion blur, noise and camera mis-focus. The noise is an unwanted electrical fluctuations in a signal. It is

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the random variation of brightness or color information in images. There are several types of noise may appear in an image. Some of them are Gaussian noise, salt & pepper noise and periodic noise. Gaussian noise is caused by poor illumination and high temperature. Salt & pepper noise randomly scatters the black, white and both pixels over the image. Periodic noise is created by electrical and electromechanical interference. In this paper, several restoration techniques are implemented to restore the original image which is blurred by adding different types of noise.

Image Restoration Steps:

Point Spread Function:

The PSF describes the response of an imaging system to a point source or point object. A more general term for the PSF is a system's impulse response, the PSF being the impulse response of a focused optical system. The images of the individual object-plane impulse functions are called point spread functions. In blind image deconvolution technique, the original images can be rebuilt from degraded images even with no prior knowledge about PSF. Nonblind deconvolution technique uses the information about the point spread function to reconstruct the image that is blurred by noise.

Image Degradation Model:

Degradation is the process by which the original image is blurred. It is characterized by the degradation model which is very complex and often unknown. The degradation process is modeled as an ordinary two-dimensional convolution given by

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

$$G(u,v)=H(u,v)F(u,v)+N(u,v)$$

where g(x,y)is the blurred noise image,f(x,y) is the original image and n(x,y) is the noise function.

Image Restoration Model:

The purpose of image restoration is to 'compensate for' or 'undo the defects' which degrade an image. It uses a priori knowledge of the degradation function. Image restoration can be achieved by modeling the degradation and apply the inverse process.

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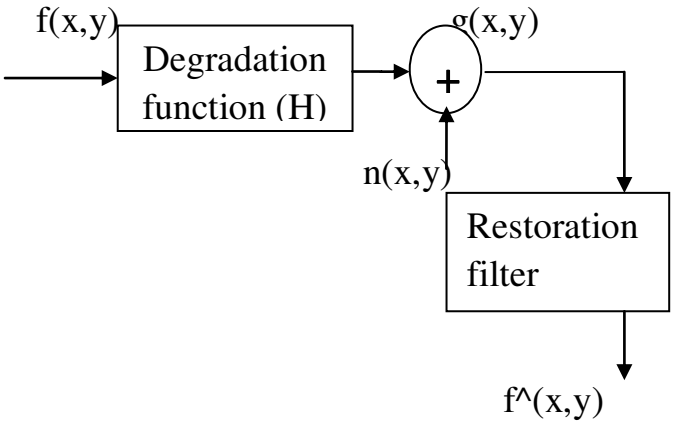
F^(u,v)=G(u,v)/H(u,v)

F^(u,v)=F(u,v) + N(u,v)/H(u,v)

Where F^(u,v) represents the restored image, G(u,v) represents the degraded image and H(u,v) represents the degradation function.



Existing Methods:

Richardson Lucy Algorithm:

It is a type of non-blind deconvolution technique as it needs to know the PSF in prior in order to blur the image. It is an iterative procedure.

$$f_{n+1} = \left(\frac{S_c}{h * f_n} * \hat{h}\right) f_n$$

This algorithm is very easy to implement and it preserves edges, as it is a nonlinear method. A problem with this method is the noise amplification and the blurring produced by the attenuation of high frequency components. It may produce speckle noise when too much L-R iterations are performed. [6] proposed a principle in which the division is the urgent stage in iris acknowledgment. We have utilized the worldwide limit an incentive for division. In the above calculation we have not considered the eyelid and eyelashes relics, which corrupt the execution of iris acknowledgment framework. The framework gives sufficient execution likewise the outcomes are attractive. Assist advancement of this technique is under way and the outcomes will be accounted for sooner rather than later.

Iterative Blind deconvolution algorithm:

In this algorithm, the degraded image is processed with an unknown blurring function. So the reconstruction process involves in the estimation of blurring function. Here the original image can be obtained by iterating between updated the restored image and the PSF. This algorithm can be performed either iteratively or non-iteratively. But it has limitations in handling natural image blur especially when complex-structure of noise and PSF are present.

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Proposed Method:

The proposed efficient blind deconvolution algorithm can be obtained by combining both blind and non blind deconvolution algorithm. This algorithm provides high restored image quality. It is based on image fusion technique.

Image fusion is the process of combining relevant information of two or more images into a single image is first transferred in to frequency domain. It means that the Fourier Transform of the image is computed first. Sometimes both the spatial and high spectral information of a single image are needed. Image fusion metrics are based on the features, structural similarity, information theory or human perception.

image. The resulting image will be more informative than any of the input images. Image fusion combines the coefficients of both the images. Image fusion technique is broadly classified into two groups. They are Spatial domain fusion method and Transform domain fusion. Spatial domain techniques directly deal with the image pixels. The pixel values are manipulated for getting desired result. In frequency domain fusion, the

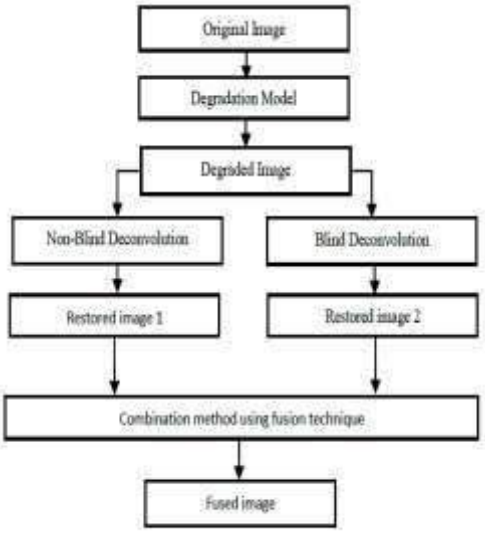

Fig: Proposed Method

Performance evaluation:

The basic requirements of an image fusion technique are that it should preserve all valid and useful information from the original images, while at the same time it does not

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produce any artifacts that could interfere with subsequent analyses.

The performance of different deconvolution algorithms are analyzed based on the metrics such as PSNR, MSE and RMSE. This can be given as,

$$MSE = \frac{\sum\left(f(i,j) - \hat{f}(i,j)\right)^2}{rows \times colns}$$

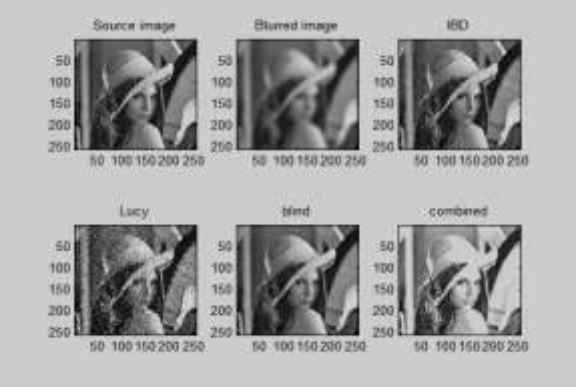
Where

f(i,j) represents the original image and $\hat{f}(i,j)$ represents the filtered image.

PSNR is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of the original image. The Peak Signal to Noise Ratio is represented in terms of mean square error. Then the Peak Signal to Noise Ratio (PSNR) can be given by,

$$PSNR = 10\log_{10}\frac{255\times255}{MSE}$$

Results of Image restoration:



Technique	Peak Signal to Noise Ratio	Root Mean Square Error
Richardson Lucy algorithm	17.377660	34.622382
Iterative Blind Deconvolution	24.220483	15.747651
Blind Deconvolution	19.668350	26.596377
Combined Method	25.613379	13.414392

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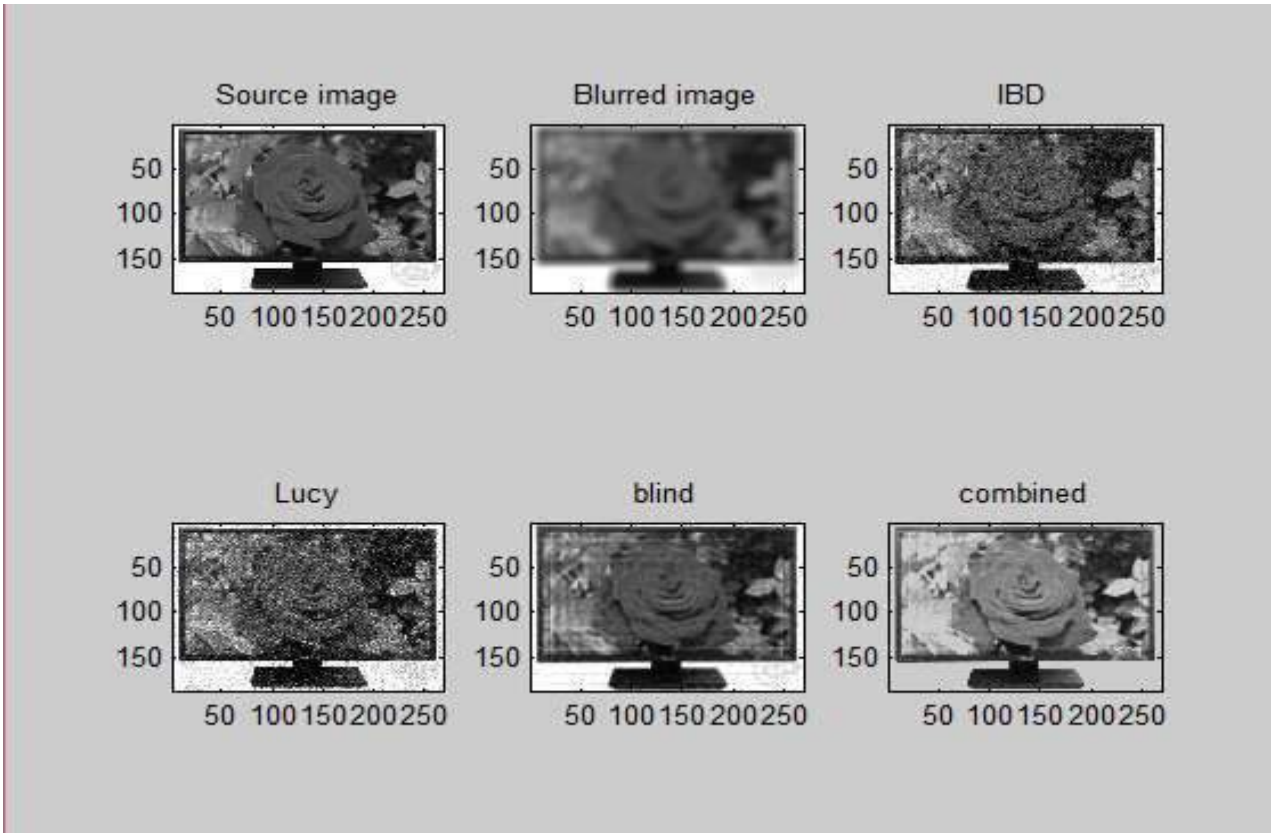

Technique	Peak Signal to Noise Ratio	Root Mean Square Error
Richardson Lucy algorithm	17.895186	32.619753
Iterative Blind Deconvolution	22.257924	19.739845
Blind Deconvolution	20.321076	24.670967
Combined Method	24.431990	15.368819

Conclusion:

This paper describes several restoration techniques that help in recovering the original image that has been blurred by noise. The performance of these techniques can be evaluated by using several criteria such as PSNR, MSE and RMSE. The proposed combination of two restored images that was generated from both blind and non blind deconvolution algorithm would result in a high quality restored image better resolution.

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