A Comparative Analysis of Image Deblurring using Deconvolution

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Abstract

The images obtained from the different sensors or satellites are degraded and unsuitable for human perception or any further process due to many parameters like noises in the environment or blurring of the image during image acquisition or during processing of the image. 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 blurry content in the image. Image restoration is the process of recovering the original image from the degraded image.

Keywords: *Deblurring, deconvolution, blurs, motion blur, Gaussian blur.*

1. Introduction

Image Processing is a technique to enhance the raw images received from the sensors placed on satellites, space probes and aircrafts or pictures taken in normal day-to-day life for various applications for which they were first developed. The result obtained by processing has a greater quality with clear visibility of the objects present in the sensed image. Image processing can be used in remote sensing, medical imaging, forensic studies, textiles, material science, military, graphic arts, printing industry, etc. Some of the fundamental steps involved in image processing are image representation, image preprocessing, image enhancement, image restoration, image reconstruction and image data compression. In this paper, a novel approach for image restoration has been explained.

Images are produced to record or display useful information. But due to imperfections in the imaging and capturing process, however, the recorded image invariably represents a degraded version of the original scene. The degradations may have many causes, but the two types of degradations that are often dominant are noise and blur, each of which introduces peculiar problems in image restoration. Blurring is a form of bandwidth reduction of the image due to imperfect image formation process. It can be caused by relative motion between camera and original images or an out-of-focus camera. When aerial photographs are produced for remote sensing purposes, blurs are introduced by atmospheric turbulence, aberrations in the optical system, and relative motion between the camera and the ground. Noise can be defined as any undesired information that contaminates an image. The principal sources of noise in digital images arise during image acquisition and/or transmission.

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In this paper, two out of the various known methods for image deblurring have been studied, compared and the best one out of them is chosen for further processing. The paper aims to present a better restored image with minimum amount of blurring present in it.

Blind image restoration is the process of estimating both the true image and the blur from the degraded image characteristics, using partial information about the imaging system [1].

2. Literature Review

Various research and review papers have been published over the past many years. Various parameters have been used to compare the results of different approaches and conclude the best one out of all the deblurring and denoising techniques.

Yi et al. 2011 [2] "A Blind Image Deconvolution Method Based on Noise Variance Estimation and Blur Type Reorganization" performed image deblurring by using Blind deconvolution method. The authors explained that there are 3 main types of blurs that mainly affect the images namely, Motion blur, Defocus blur and Gaussian blur. A novel blind image restoration method based on noise variance estimation has been implemented on various blurs and images are restored.

Javed et al. 2011 [3] "Multichannel Blind Image Deconvolution" explained that PSF plays a major role in Wiener Filter and Blind Deconvolution techniques. The authors concluded that blind deconvolution method can be used to explore the unknown PSF and restore true image.

Ramya et al. 2013 [4] "Restoration of blurred images using Blind Deconvolution Algorithm" described the performance Blind Deconvolution method after degradation of the image using Degradation Model.

Biswas et al. 2011 [5] "Deblurring Images using a Wiener Filter" performed image deconvolution on the blurred images using Weiner Filter.

3. Proposed Work

In this paper we lay focus on 2 deblurring techniques namely, Weiner Filter and Blind Deconvolution and the denoising technique, Discrete Wavelet Transform.

The existing conventional Deblurring methods work well when there is no noise present in the image. Under high noise content, Deblurring techniques do not work effectively. Also, noise is unavoidable and it makes the image defective for further use. Further, even if the type or proportion of blur in a blurred image is unknown, the deblurring cannot be carried out properly. Thus, there is a need for a new technique that works well with image blurring as well as noise.

First image deblurring technique is applied and thus a deblurred image is obtained. Then image denoising technique is applied to the same raw image and we get a denoised image. Then both the techniques will be fused and applied together in order to give a resultant superior quality image that is free from any blur or noise. Thus the results of previously single applied techniques can also be compared with the fused method result and displayed in terms of various performance parameters.

4. Deblurring Techniques

4.1 Weiner Filter

It is effective in the presence of both, blur and noise.
It requires a known PSF which may be regarded as a disadvantage.
Let T(u,v) be a linear shift-invariant reconstruction filter.

$$\hat{F}(u,v) = G(u,v)T(u,v) \quad (1)$$

Where $\hat{F}(u,v)$ is the deblurred image and *G(u,v)* is the PSF of the image.
Result obtained has balanced noise reduction and sharpening of the image.

$$G(u,v) = F(u,v)H(u,v) + N(u,v) \quad (2)$$

If we multiply the entire equation with $H^{-1}(u,v)$ then filtered noise is observed in the resultant image as shown in (3).

$$\hat{F}(u,v) = F(u,v) + N(u,v)H^{-1}(u,v) \quad (3)$$

So we take Butterworth response & select it such that image is not distorted & noise is still suppressed.

$$T(u,v) = \frac{B(u,v)}{H(u,v)} \quad (4)$$

The frequency-domain expression for the Wiener filter is as in (5).

$$T(u,v) = \frac{H^*(u,v)}{|H(u,v)|^2 + K} \quad (5)$$

4.2 Blind Deconvolution

This method estimates PSF from one or more images and then uses it to recover an estimate of F(u, v).
Assume that |H(u, v)| is a smooth function and ignore noise.
Expressing |F(u, v)| as the sum of slowly and rapidly varying components.

$$|F(u,v)| = |F(u,v)|_L + |F(u,v)|_H \quad (6)$$

Then,

$$G(u,v) = |H(u,v)||F(u,v)|_L + |H(u,v)||F(u,v)|_H \quad (7)$$

Now the low frequency term is extracted using a smoothing filter S(u, v).
So we get,

$$S(u,v)|G(u,v)| \approx |H(u,v)||F(u,v)|_L \quad (8)$$

We can then estimate the blur function from (9)

$$\hat{H}(u,v) = \frac{S(u,v)\,|\,G(u,v)\,|}{F(u,v)_L} \tag{9}$$

The numerator can be constructed from the image. The denominator can be estimated from similar images.

5. Results

Two types of blurs namely, Motion blur and Gaussian blur introduced in the original image are studied and the blurred image is deblurred by Weiner filter and Blind deconvolution methods one by one. The results of each method are shown in fig. (5) and (6).

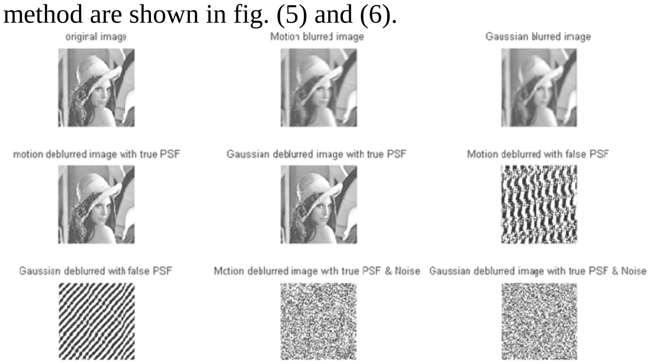

Figure 5: Deblurring using Weiner Filter

It is observed that if the PSF is unknown or faulty valued, then Weiner filter method results in a faulty outcome. Further, this method also fails when the image is affected by noise. The Blind deconvolution works well in case of unknown PSF but it too fails in presence of noise.

Figure 6: Deblurring using Blind Deconvolution

6. Conclusions

From the simulated results, it is observed that the Wiener Filter method requires a known PSF for its operation. If by any human error, the PSF value changes then this technique results in a faulty output. Further, even if the true PSF is known but there is noise present in the image, then too this technique will result in a faulty output. This is the major drawback of the Wiener Filter method.

The blind deconvolution technique on the other hand works on an unknown PSF by the trial and error method of guessing the PSF values and observing the resultant image until a result is obtained that perfectly matches the original image. This gives a major advantage over the Wiener Filter method as the knowledge about PSF is not needed. But this method too has a limitation-when working with a noisy image, it results in a faulty output.

7. Future Work

The remaining several kinds of blurs can be worked upon and which deblurring method suits them the best can be determined and the same can be used for even better results.

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