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Image Deblurring Techniques: A Review

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Abstract In this paper, the techniques of image deblurring used to remove blur or reduce it as much as possible from image are reviewed. The blur's source, and the effects of bluron images are efficiently and comprehensively reviewed together with the discussion of the classical and recent developed image deblurring techniques, including non-blind/blind, spatially invariant/variant deblurring techniques. Most of deblurring techniques basically sharpen a blurred image via different methods & parameters**.**

Blur in images is an unwanted reduction in bandwidth which degrades the image quality and it is difficult to avoid. It occurs in various types (such as Gaussian blur, motion blur, etc.) due to atmospheric turbulence as well as improper setting of camera. Nowadays, different techniques and methods are introduced to deblur a degraded image. That's for a specific type of blur, a corresponding specific method to remove may exist.

Image restoration by deblurring has its applications in many fields like medical imaging, forensic science, and astronomy. In this paper, we will discuss various image deblurring techniques and their performance analysis.

Keywords Deconvolution, Degradation model, Point spread function (PSF), Deblurring, Lucy-Richardson Algorithm, Regularized filter, Wiener filter.

1. Introduction

Modern imaging sciences, such as photography, astronomical imaging, medical imaging, and microscopy have been well developed in recent years and a large number of progressive techniques have emerged [1]. These developments have enabled the acquisition of images that are of both higher speed and higher resolution.High-resolution techniques may lead to some degradations in acquired image quality, of which blur is an example and is the focus of this paper.

Image deblurring basically results in a sharp image while removing image noise and blur. Blurring may occur due to many factors such as noise, dust, camera shake, object shake etc. Deblurring may be accomplished through different methods such as sharpening the edges, filling the pixels which are blank and removing the noise from degraded and blurry images [2].

In this paper, blur types and reasons with different deblurring techniques are described. In addition to this introduction, section 2 consists of blur types and reasons. Different techniques of image deblurring are presented in section 3. Section 4 contains Comparison of Different Deblurring Techniques. Finally, section 5 concludes this paper.

2. Blur types and Causes

In digital world there are mainly three type of blur we study mainly. These are of three types i.e.-

1- Average blur: Average blur can be scattered in both directions (Horizontal, Vertical). Average filter will remove this type of blur and it is useful when blur affects the whole image.

2- Gaussian blur: Blur which is simulated by Gaussian function. Effect of gaussian blur produced through a filter that follows a bell-shaped curve by unifying a definite no. of pixels incrementally. Such type of blurring is impenetrable in the center and at the edge side blur will fluffs.

3- Motion blur: Motion blur occurs due to comparative motion between the camera and the scene (camera shake).Motion blur effects can be simulated in an image using motion filter in a specific direction then the resulted image will appear to be moving [2]. Another examples and sources of blur like defocus blur, since most imaging systems have only one focus, the resultant images usually have at most one region that is focused while the others remain blurred. When capturing a long distance scene, atmospheric particulate matter sometimes prevents photons from moving directly to the sensor, which produces a blurred image (atmospheric turbulence blur). When a lens has a different refractive index for different wavelengths of light, the lens can fail to focus all colors to the same convergence point which also results in a blurred image (intrinsic physical blur). Image blurring based on degradation model. According to degradation model representing by Fig.1 and equation (1), original image will convolve with degraded function i.e. point spread function using convolution operator which work like a multiplication operator, then we get degraded image or blurred image [3]. An observed image $c(x; y)$, is assumed to be the two dimensional convolution of the true image $i(x; y)$ with a linear-shift invariant blur , known as Point Spread Function (PSF), $d(x; y)$ and the additive noise is assumed zero [4]. That is,

$c(x; y) = i(x; y) * d(x; y)$ ……. (1)

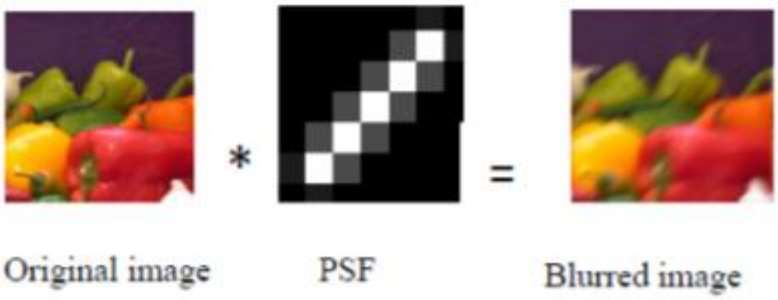

Figure 1: Image degradation model

3. Deblurring Techniques

There are many image deblurring techniques in image processing. The techniques can be classified into non-blind and blind deconvolution.

3.1 Non-Blind Deconvolution

In these techniques, we require the prior knowledge about the parameters of blur kernel Point Spread Function (PSF) that include angle and length to perform deconvolution.

These techniques can also be classified into linear like wiener filter, inverse filter, constrained least square filter and others filters with different design, and non – linear like Lucy-Richardson method. In the next sub-sections, brief discussions will be given for these methods.

3.1.1. Deconvolution using wiener filter

The Weiner filter is one of most general technique used for deblurring the degrade image. This technique was proposed by Nobert Weiner in 1940. It helps to remove out the Gaussian blur from the images. Generally linear time invariant filtering technique is used for removing out the corrupted sort of signals. Which reconstructs an image from degraded image by using known PSF. It works with high pass filter to perform Deconvolution as well as with low-pass filter to remove noise with compression operation [5].

3.1.2. Deconvolution using Inverse Filter

The blurring function of the corrupted image is known or can be developed then it has been proved as quickest and easiest way to restore the distorted image. Blurring can be considered as low pass filtering in inverse filtering approach and use high pass filtering action to reconstruct the blurred image without much effort.

Suppose first that the additive noise is negligible. A problem arises if it becomes very small or zero for some point or for a whole region in the plane then in that region inverse filtering cannot be applied [6].

3.1.3. Deconvolution using Regularized filter

Regularized filter or called Constraint Least-Square 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 [6].

3.1.4 Adaptive filter

Adaptive filter is type of linear filter that has transfer function controlled by variable parameter. Adaptive filter use the color and gray space for removal of impulsive noise in images. All processing is done on the basis of color and gray space. Adaptive filter are used to remove the effect of speckle noise. This can provide the best noise suppression results and better preserve edges, thin lines and image details and yield better image quality in comparison to other filters [7].

There is several researchs that suggest others filters with different designs and also many research that modifies the PSF.

3.1.5 Laplacian Sharpening Filter

The Laplacian filter is a very well-known example of a second order derivative method of image enhancement which is used for image sharpening means indirectly for image deblurring. It is significantly good at finding the fine specifications in a blurred image. Any feature with a sharp discontinuity will be enhanced by a Laplacian filter which smoothened the image by deblurring it.

Laplacian Sharpening highlights regions of rapid intensity change and therefore highlights or enhances the edges. The output of a Laplacian filtering technique is not an actual clear image but we have to do somewhat more work so that we get our final image. Basically the mathematical operation like subtract or add the actual Laplacian output from the original image to give out our final sharpened enhanced restored image [8].

3.1.6. Deconvolution using Lucy-Richardson

The Richardson–Lucy is the most popular technique in the field of astronomy and medical imaging .The reason of popularity is its ability to produce reconstructed images of good quality in the presence of high noise level. Lucy and Richardson found this in the early 1970’s from byes theorem. Lucy Richardson is nonlinear iterative method. This method is gaining more acceptance than linear methods as better results are obtained here [8]. The LR algorithm can be used efficiently in that case where the point-spread function PSF (blurring operator) is identified, but modest or no information is available for the noise. It is an iterative method to restore blurred image which is blurred by known PSF. One main problem with basic LR method is how many times process should repeat [9].

3.2. Blind Deconvolution Techniques

There are basically two types of blind deconvolution methods. They are projection based blind deconvolution and maximum likelihood restoration. In the first approach it simultaneously restores the true image and point spread function. This begins by making initial estimates of the true image and (PSF). Firstly we will find the PSF estimate and it is followed by image estimate. This cyclic process is repeated until a predefined convergence criterion is met. The merit of this method is that it appears robust to inaccuracies of support size and also this approach is insensitive to noise, the problem here is that it is not unique and this method can have errors associated with local minima. In the second approach the maximum likelihood estimate of parameters like PSF and covariance matrices. As the PSF estimate is not unique other assumptions like size, symmetry etc. of the PSF can be taken into account. The main advantage is that it has got low computational complexity and also helps to obtain blur, noise and power spectra of the true image. The drawback with this approach is of algorithm being converging to local minima of the estimated cost function [10].there is anthers blind techniques like Neural Network Approach.

Neural networks are a combination of different types of learning algorithms which are inspired and taken by biological neural networks and are used to calculate or approximate functions that can depend on a huge number of inputs and are actually unknown. Artificial neural networks are usually presented as systems of interconnected sets or unique "neurons" which can computing values from inputs, and are capable of performing machine learning as well as pattern recognition. To determine organization and control of the function involved in it systems use algorithms in their programming. The Neural network doesn't require any prior knowledge as it used to know the blurred in learning phase in hidden layer. Actual knowledge of signals, pixels and blurred patch is known by estimating actual relationship between degraded pixel in supplied blur image and corresponding pixels in original image [11].

4. Comparison of Different Deblurring Techniques

Different methods were discussed so far, and to make comparison between the Performance analyses of deblurring techniques in clear form we did the table below, depending on different papers and some of which are mentioned in this paper.

Table 1: Comparison Table

Method name	Type of blur	Performance
Weiner Filter	Gaussian	bad
Regularized filter	Gaussian	Efficient
Inverse Filter	Motion blur & out of focus	Efficient
Adaptive filter	Gaussian	Efficient
Laplacian Filter	Gaussian	Efficient
Lucy-Richardson	Gaussian	Efficient
Blind deconvolution	Gaussian & Motion	Efficient
Neural Network	Gaussian &out of focus	Very Efficient

5. Conclusion

A number of techniques have been developed by different researchers for image deblurring till now, image deblurring is a challenging issue. From the comparative study of techniques to remove or reduce the blur from images, it can be concluded that most algorithms (specialized in Gauss) are the predominant, while other algorithms techniques are concerned with other types of blur; such as focal or motion blur. Every technique when seen independently it is good in its own criteria. Some algorithms are linear while some are non-linear. But still when taken all together neural network approach is much better. Having a higher value for image PSNR is a good quality metric because it means that the ratio of peak signal-to-noise is higher. Having certain prior knowledge about noise and blur the iterative Lucy-Richardson Algorithm gives better results. Blind deconvolution method is gives best result in comparison with non-blind techniques.

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