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Blurred Image Restoration Using Canny Edge Detection and Blind Deconvolution Algorithm

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***Abstract*—Restoring the original image from blurred or degraded image due to motion blur, noise or camera misfocus has long been a challenging problem in digital imaging. Image restoration is thus a process of recovering the actual image from the degraded image. The purpose of the paper is to restore the blurred/degraded images using blind deconvolution algorithm with canny edge detector. The task of image deblurring is to deconvolute the degraded image with the point spread function (PSF) that describes the distortion. Firstly the original image is degraded using degradation model. It can be done by low pass filters like Gaussian filter or others to blur an image. The ringing effect at the edges of blurred image can be detected using Canny Edge Detection method. Blind deconvolution algorithm is applied to the blurred image where image recovery is performed with little or no prior knowledge of the degrading PSF.**

I. Introduction

Images are produced to record or display useful information. Image restoration refers to the recovery of an original signal from degraded observations. The purpose of image restoration is to "compensate for" or "undo" defects which degrade an image. Degradation comes in many forms such as motion blur, noise, and camera misfocus. The undoing of these imperfections is crucial to many of the subsequent image processing tasks. Blurring is a form of bandwidth reduction of an ideal image owing to the imperfect image formation process. It can be caused by relative motion between the camera and the original scene or by an optical system that is out of focus. In addition to these blurring effects, noise always corrupts any recorded image. Noise may be introduced by the medium through which the image is created (random absorption or scatter effects), by the recording medium (sensor noise), by measurement errors due to limited accuracy of recording system and by quantization of the data for digital storage. The process of image restoration is dependent on whether the information about degradation process is provided or not.

The degradation process is usually modeled as a convolution.

$$g = f * h + n \qquad \text{--- (1)}$$

where the g is the blurred, noisy image i.e. the data available, f is the original image, h is the point spread function modeling the blurring and n is the noise added to blurred image. Image restoration methods can be categorized in to two classes dependant on degradation process such as Image Deconvolution and Blind Image Deconvolution.

Image deconvolution is a linear image restoration problem where the parameters of the true image are estimated using the observed or degraded image and a known PSF (point spread function). Blind image deconvolution is more difficult image restoration. There is a very little or no information about the point spread function in it. The advantages of deconvolution are higher resolution and better quality. Image deblurring is an inverse problem whose aspire is to recover an image which has suffered from linear degradation. The blurring degradation can be space invariant or space in variant. Inverse problems are often ill-posed [4]. Existing blind deconvolution methods are a priori blur identification method, zero sheet separation method, ARMA parameter estimation methods and nonparametric methods [1].

A priori blur identification methods are the class of methods that perform the blind deconvolution by identifying the PSF prior to the restoration. Typically these methods assume the PSF to be of a known parametric form. The associated parameters are unknown and to be determined before restoration. This method is relatively simple but have some major drawbacks like they require the knowledge of the form of PSF, some PSFs simply don't have frequency zeros. Finally additive noise can mask the frequency domain nulls and thus degrade the performance.

One difficulty in the blind deconvolution problems is the lack of sufficient 2D polynomial algebra. If we take the Z-transform of (1) dropping the noise term, we obtain

$$G(z_1, z_2) = F(z_1, z_2).H(z_1, z_2) \qquad \text{---- (2)}$$

The blind deconvolution problem would be solvable if G (z_1,z_2) can be factorized. The zero sheet separation is such a factorization scheme. It provides valuable insight into the blind deconvolution problems in multiple dimensions.

But it is highly sensitive to noise. Blind deconvolution using ARMA parameters estimation models the true image as an autoregressive process (AR) and the PSF as a moving average (MA) process. The advantage associated with this method is that they are less sensitive to noise because models already take into account the noise[1]. Initially, D. Kundur and D. Hatzinakos proposed the restoration procedure involves recursive filtering of the blurred image to minimize a convex cost function blindly. The feasibility has been confirmed when it is applied on a scene consists of a finite support object against a uniformly black, gray, or white background [6].

After that different advanced conditions for BID have been addressed and improved. For instance, since the requirement of a hard decision on whether the blur satisfies a parametric form before their formulations in these algorithms, the precondition inhibits the incorporation of parametric blur knowledge domain into the restoration schemes. The recursive soft decision approach is proposed by K.H. Yap and el al. Further, they proposed a computational reinforced learning scheme to overcome the drawbacks of conventional methods, for instance, inter-domain dependency and falling into a local solution. C. Vural and el al. thought that conventional methods require either a special parametric PSF form or complex computation [7]; hence, they proposed a non-linear adaptive filtering to minimum dispersion of image. Because this method does not impose constraints on the phase of the blur, its implementation is easy for real applications [6]. Recently, aiming at seek a higher quality of restoration; several evolutionary techniques have been introduced, for example genetic algorithm [2]. The feasibility and benefits are verified by simulation results in [2]. Most of these algorithms belong to a priori blur identification method because the parameters of blur model are suitably committed to the evolutionary learning. In the preliminary studies, we have utilized particle swarm optimization (PSO) to tackle different issues about BID problem [2], [6].

This paper is structured as follows: First step is to describe the degradation model for blurring an image. In the next step the ringing effect at the edges of the blurred image will be detected by using Canny Edge Detection method. Then the blurred image should be the input to the deblurring algorithm. Various algorithms are available for deblurring. The blind deconvolution algorithm can be used to deblur the image.

II. BLURRING OR DEGRADATION MODEL

The blurring of an image is modeled as the convolution of an ideal image with two dimensional point spread function as following [5]:

$$g(x,y) = f(x,y) * h(x,y) + n(x,y) \quad \text{--- (3)}$$

Where g(x,y), f(x,y),h(x,y) denotes the observed blurred image, original image and point spread function(PSF) respectively. The n(x,y)is the additive noise. The following figure 1 represents the structure of degradation model.

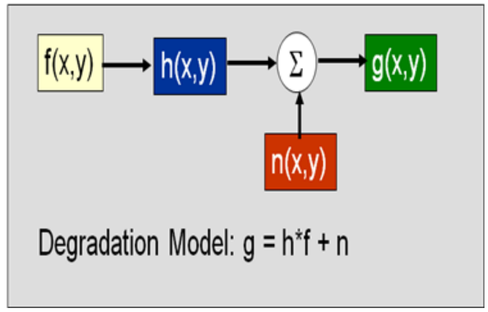

Figure 1 Degradation Model

Image deblurring can be done by the technique, Gaussian Blur. It is the convolution of the image with 2-D Gaussian function [3].

A) Gaussian Filter:

Gaussian filter is used to blur an image using Gaussian function. It requires two parameters such as mean and variance. It is weighted blurring. Gaussian function is of the following form where σ is variance and x and y are the distance from the origin in the horizontal axis and vertical axis respectively. Gaussian Filter has an efficient implementation of that allows it to create a very blurry blur image in a relatively short time.

B) Gaussian Noise:

The ability to simulate the behavior and effects of noise is central to image restoration. Gaussian noise is a white noise with constant mean and variance. The default values of mean and variance are 0 and 0.01 respectively.

C) Blurring Parameter:

The parameters needed for blurring an image are PSF, Blur length, Blur angle and type of noise. Point Spread Function is a blurring function. When the intensity of the observed point image is spread over several pixels, this is known as PSF. Blur length is the number of pixels by which the image is degraded. It is number of pixel position is shifted from original position. Blur angle is an angle at which the image is degraded. Available types of noise are Gaussian noise, Salt and pepper noise, Poisson noise, Speckle noise which are used for blurring. In this paper, we are using Gaussian noise from MATLAB which is also known as White noise. It requires mean and variance as parameters.

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D) *Algorithm*

For Degradation Model [3]

Input:
Load an input image 'f'
Initialize blur length 'l'
Initialize blur angle 'theta'
Assign the type of noise 'n'
PSF (Point Spread Function), 'h'
Procedure – I
h=create (f, l, theta) %Creation of PSF
Blurred image (g) = f*h + n
g= filter (f, h, n,"convolution")
If 'g' contains "ringing" at its edge then remove ringing effect using edge taper function
Else
Go to Procedure – II
End Procedure – I

III. Canny Edge Detection And Ringing Effect

The Discrete Fourier Transform used by the deblurring function creates high frequency drop-off at the edges of images. This high frequency drop-off can create an effect called boundary related ringing in deblurred images. For avoiding this ringing effect at the edge of image, we have to detect the edge of an image. There are various edge detection methods available to detect an edge of the image. The edge can be detected effectively using Canny Edge Detection method [3]. It differs from other edge-detection methods such as Sobel, Prewitt, Roberts, Log in that it uses two different thresholds foe detecting both strong and weak edges. Edge provides a number of derivative (of the intensity is larger than threshold) estimators. The edge can be detected for checking whether there exists ringing effect in an input image.

A) *Canny Edge Detector*

Canny edge detection method finds edges by looking for local maxima of the gradient of f(x, y). The gradient is calculated using the derivative of a Gaussian Filter. The method uses two thresholds to detect strong and weak edges, and includes the weak edges in the output only if they are connected to strong edges [3]. Therefore, this method is more likely to detect true weak edges.
1) Steps involved in canny method:

o The image is smoothed using Gaussian Filter with a specified standard deviation, σ, to reduce noise

o The local gradient, g(x, y) and edge direction are computed at each point.

o The edge point determined give rise to ridges in the gradient magnitude image. This ridge pixels are then thresholds, T1& T2, with T1<T2.

Ridge pixels with values greater than T2 are said to be 'strong' edge pixels. Ridge pixels with values between T1 & T2 are said to be 'weak' edge pixels.

B) Edgetaper for Ringing Effect:

The ringing effect can be avoided using edge taper function. Edgetaper function is used to preprocess our image before passing it to the deblurring functions. It removes the high frequency drop-off at the edge of an image by blurring the entire image & then replacing the center pixels of the blurred image with the original image.

IV. Overall Architecture And Deblurring Algorithm

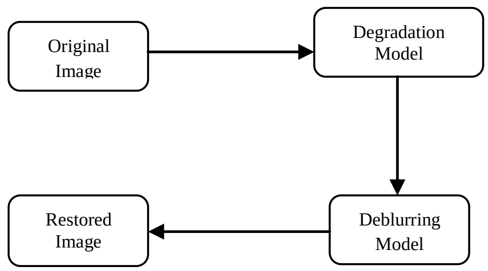

Figure 2 Overall architecture of Restoration

The following Fig. 2 represents the overall architecture of this paper. The original image is degraded or blurred using degradation model to produce the blurred image. The blurred image should be an input to the Deblurring Model. Various algorithms are available for deblurring. In this paper, we are going to use Blind Deconvolution Algorithm. The result of this algorithm produces the deblurring image which can be compared with our original image.

A. Blind Deconvolution Algorithm:

Blind Deconvolution Algorithm can be used effectively when no information of distortion is known. It restores image and PSF simultaneously. This algorithm can be achieved based on Maximum Likelihood Estimation (MLE).

1) Algorithm for Deblurring:

Input:
Blurred image 'g'
Initialize number of iterations 'i'
Initial PSF 'h'
Weight of an image 'w' % pixels considered for restoration
a=0 (default) %Array corresponding to additive noise
Procedure – II
If PSF is not known then
Guess initial value of PSF

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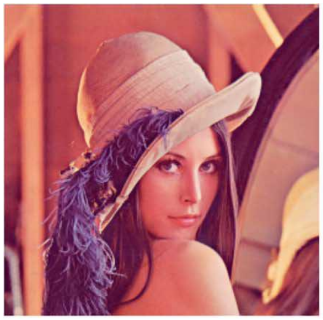
Else
Specify the PSF of degraded image
Restored Image f'= Deconvolution (g, h, i, w, a)
End Procedure – II

V. Sample Results

The below images represent the result of degradation model using Gaussian blur. First image represents the original image and its edge can be estimated by Canny Edge detection method.



Original Image

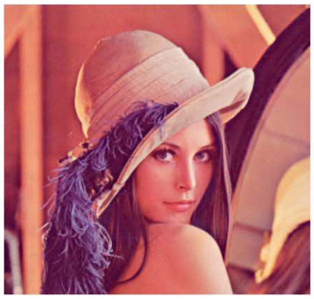
The edge detection can be applicable to Gray Image.Therfore the original RGB image can be converted to gray image. After that Canny Edge Detection is applied for getting the Edges of the original image.

Edges of Original Image

The original can be blurred using Gaussian low pass filter by specifying the blur parameters. The following image is depicted as blurred image.

Blurred Image

The sample image after applying the proposed algorithm will be as follows



Restored Image [4]

VI. Conclusion

This paper analyzes that Blind Deconvolution method does not require any prior information on the kernel while other techniques usually need user interactions to have some accurate information of the blurring as the input. Gaussian Filter has an efficient implementation that allows it to create a very blurry image in a relatively short time. Again the Canny Edge detection have better performance results than the other methods like Sobel,Roberts etc.

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