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Blind Image Deconvolution using Frequency Spectrum in Motion Blur Estimation

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Abstract: Image deconvolution refers to the act of minimizing the blur quantity from a blurred image and discovers the sharp and clear original image [7].The blind image deconvolution (BID), refers to the task of separating two convolved signals.We have taken motion blur estimation method which will extract the features from the frequency domain of the image. This method has low complexity as compare to other estimation methods like radon, steerable filter methods.

Keywords: Image Deconvolution, Point Spread Function (PSF), Frequency, Motion Blur

I. INTRODUCTION

Image deconvolution refers to the act of minimize the blur quantity from a blurred image and discover the sharp and clear original image. It uses a point spread function (PSF also known as blur kernel) to deconvolve the blurred image.
There are four types of blur effects in digital camera [14].Average blur is a tool to remove noise and specks in an image. It is used when noise is present over the entire image. Second is motion blur. It is degradation in a photograph of any moving object or imaging system itself. Motion blur causes significant degradation of the image[1][11]. A gaussian blur is the result of blurring of an image by gaussian function. This blur has good capability to reduce image noise. Hence it iscommonlyused in graphics software. The Gaussian blur effect is a filter that blends a specific number of pixels incrementally, following a bell-shaped curve [9]. Gaussian blur is also used as a pre-processing stage in computer vision algorithms in order to enhance image structures at different scales. Out-of-focus Blur occurs when a camera images a 3-D scene onto a 2-D imaging plane. This causes some parts of the scene in focus while other not. There are many methods for deblurring a blurred image.
The blind image deconvolution (BID), refers to the task of separating two convolved signals, iand d, when both the signals are either unknown or partially known[7]. A lot of research has been done exploring the various methods for image deconvolution as blind techniques. But still, it is a critical and challenging problem for the researchers.

II. LITERATURE SURVEY

A.S. Mane, Prof. Mrs. M. M. Pawar [1] has worked on a new effective blind deconvolution algorithm which can effectively remove complex motion blurring from natural images without requiring any prior information of the motion-blur kernel. In degradation model for blurring image, the image is blurred using filters and an additive noise. After this, apply restoration process to restore image using blind deconvolution technique. Estimate PSF of different size of initially blurred image then apply canny edge detector to remove ringing effects from restored image. Limitation of this algorithm was large number of steps were there of deconvolution process.
Ashwini M. Deshpande and Suprava Patnaik [2] has proposed an algorithm based on sparse representation of images and adaptive dictionary learning, features one of the successful repositories in removal of uniform and non-uniform motion blur from a single blurred-noisy image. Comparative performance analysis performed with some of the leading deblurring algorithms proves the effectiveness of the proposed method in handling blurs like linear blur, camera shake, hand shake etc. These algorithm works for both uniform and non-uniform motion blur.
Sunghyun Cho, Yasuyuki Matsushita, Seungyong Lee[3][12] has proposed a new method for removing non-uniform motion blur from multiple blurry images. First, it proposes a new approach to restoring images that are contaminated by spatially-varying motion blurs. Second, in addition to the restoration, associated motion blur kernels, segmentation, and motions are simultaneously obtained. This algorithm has a few limitations too.
C. Paramanand and A. N. Rajagopalan [4] addressed the problem of estimating the latent image of a static bilayer scene (consisting of foreground and background of different depths).They initially propose a method to estimate the transformation spread function (TSF) corresponding to one of the depth layers. The estimated TSF (which reveals the camera motion during exposure) is used to segment the scene into the foreground and background layers and determine the relative depth value. The deblurred image of the scene is finally estimated within a regularization framework by accounting for blur variations due to camera motion as well as depth.
ShamikTiwari, V. P. Shukla, A. K. Singh, S. R. Biradar [14] described an estimate to the angle of blur kernel and length of blur kernel. After estimation they used these estimated parameters to deblur the image using various algorithms. Hough transformation method, Radon transformation method, Steerable filters method are used to estimate the blur kernel and blur length.
Hanghang Tong, Mingjing Li, Changshui Zhang [6] proposed a scheme that uses the harr wavelet transform (HWT) in discriminating different types of edges as well as recovering sharpness from the blurred version, and then

determines whether an image is blurred or not and up to what extent if it is blurred. Then construct edge map and find local maxima in each window. This method is effective and efficient to judge whether or not an image is blurred according to whether or not it contains any dirac-structure or astep-structure.

Jao P. A. Oliveira, Mario A. T. Figueirado, Jose M. Biouceas-Dias [15]described an approach i.e. radon transform (RT) method to estimate the parameters of a motion blur (direction and length) directly from the observed image. RT method work for both long and short length. Radon transform computes the projection of an image along specified directions. Detecting those minima and averaging the distances between them, we can compute the final blur length.

III. METHODOLOGY

In this research work, image restoration process is performed by blind deconvolution technique with blur parameters estimation to remove motion blurs. Block diagram (figure 1) shows six steps followed for image restoration.

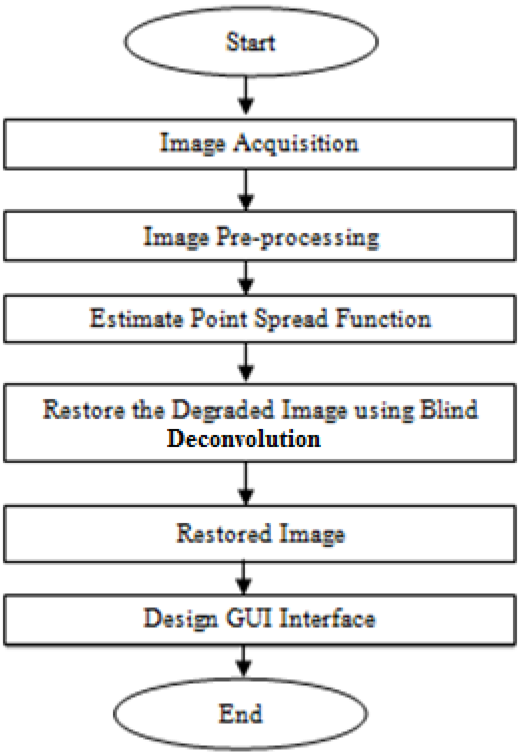

Figure1: Flow Chart of Image Deblurring

The process starts with image acquisition. We have collected some images from internet and some images are captured by camera. All images are stored in a database.

Image Pre-processing

Second step is to perform some operations on input image to make it suitable for further operations. Here, we have resized all images to (200,200). Convert RGB image into grayscale. We will remove noise also from images which may occur at the time of capturing an image. For removal of noise, we are using median filter. Figure 2 shows RGB original blurred image. Figure 3 shows grayscale image. To extract the motion blur parameters, we transform the motion blurred image in frequency domain. Frequency spectrum of motion blurred image shows the dominant parallel lines orthogonal to the motion orientation with very low values near to zero. Therefore, the task of estimating the motion orientation is analogous to the task of calculating orientation of these parallel lines. We have used fast fourier transform (fft) method. Figure 4 represents frequency domain of grayscale image.

Figure 2: RGB Original image

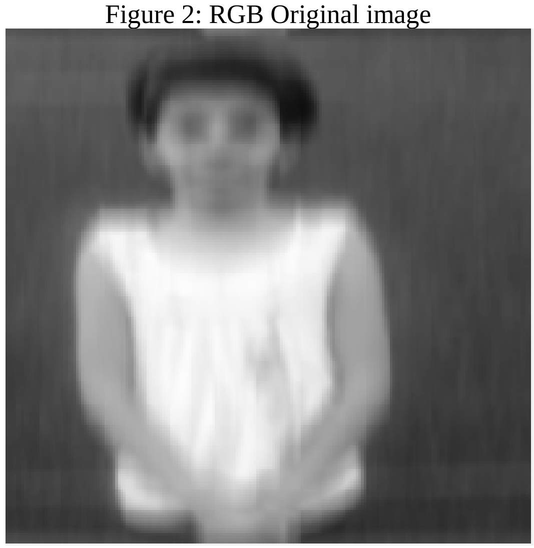

Figure 3:Grayscale Image

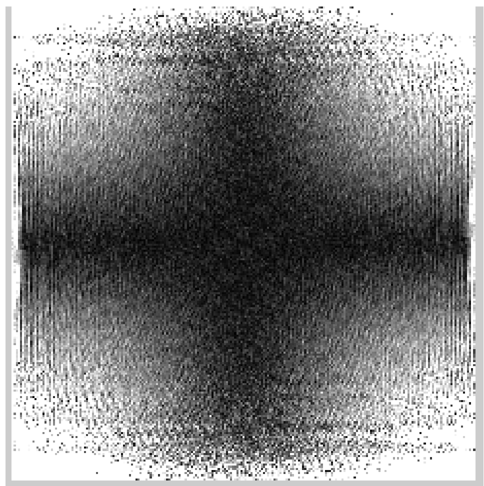

Figure 4: Frequency Domain

Estimation of Point Spread Function

Any type of blur is characterized by the point spread function (psf)[16][17]. The quality of any imaging system depends on the degree of spreading (blurring) of the point object. Point spread function describes the imaging response to a point input and is analogous to the impulse response [9].Motion blur can be modeled by a point spread function. Motion blur has two parameters: angle (theta) and length[11].

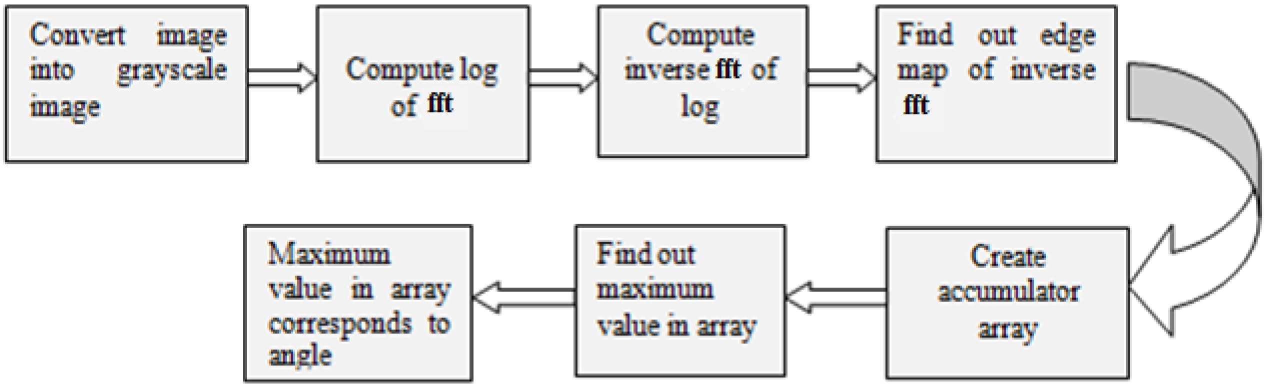

Figure 5: Steps for Blur Angle Estimation

Angle (theta) describes the direction of blur and other one is length which describes the length of blurred pixels. In case of blind restoration of motion blurred images, accurate estimation of these parameters is required. For estimation of blur angle and length we have various methods. Figure 5 shows step for blur angle estimation.

Blind Deconvolution

The deconvolution process or reconstructing process can be subdivided into two categories[10] as:

- Non-Blind Restoration
- Blind Image Restoration

Classical or non-blind restoration [13] includes the techniques that utilize some prior information about the degradation of image during reconstruction.

Blind image restorationis the process of estimating both the true image and the blur from the degradedimage characteristics, using partial information or no information about the imagingsystem. In classical restoration, the point spread function (PSF) is given and the degradationprocess is applying reverse to degradation model using one of the many restoration algorithms.

In blindimage deconvolution, a blurred image g(x, y), is assumed to be the two dimensionalconvolution of the true image i(x, y) with a linear-shift invariant blur i.e. d_f, known as point spread function[10][13][17]. The problem of reconstructing the true image i(x, y) requires the deconvolution of the PSF, d(x, y) from the blurred image, g(x, y).

On the basis of binary image (output of edge () method), hough transform method will create an array which is known as accumulator array according to those points which are perpendicular between origin and line. It will take all those points on the edge map of image which are perpendicular between the origin and the line. The distance between the point and the origin gives length. Then pair wise value (r, θ), which is angle and their corresponding length will store in accumulator array. Maximum value in accumulator array corresponds to the angle or blurs direction.

Now, blind deconvolution method will execute and give restored image according to these estimated values of length and theta. First of all it will create a PSF of estimated values of angle and length and then perform deconvolution operation on the blurred image.

In this step, apply hough transform method on the edge map of inverse fft to get estimated values of angle and length.

Estimated values of angles: 91 85 97 178 79 105 73 113 3 18

Estimated values of angles: 22 represent value of length corresponding to angle 91.

Here we have set no. of estimation is 10. We can set no. of angle estimation to 11 or 12 or any other value like 15 but every time values will start repeating and if we will increase the no. of estimation values then time will also increase as well because we have to check which pair of {length, angle} giving best restored image.

Table 1 No. of Angle Estimation is 10

Angle	Length
179	48
46	15
2	14
39	14
52	13
170	13
11	13
22	14
71	14
28	14

Table no. 1 representing 10 values of estimated angles for an image which is degraded by PSF with angle 45 and length 15.

Apply blind deconvolution on the basis of estimated values of angle and length then we get restored image.

Figure 6: Restored Image

Sometimes restored image still has some ringing effects after deconvolution so to improve the clarity of image we perform some further operations.

Figure 7: Final Restored Image

IV. RESULTS AND CONCLUSION

For estimation of blur parameters we have used hough transform method. We experimented with three parameters that are PSNR, MSE to throw light on the important characteristics of an image like denoising, error, randomness etc. Multiple experiments are done over various images to measure the accuracy of system. Apart from accuracy of proposed system we did many experiments to identify which one of feature is most effective for image restoration.

We have taken motion blur estimation method which will extract the features from the frequency domain of the image. This method has low complexity as compare to other estimation methods like radon, steerable filter methods. By using this estimated method, blind deconvolution method gives a better quality restored image as compared to image deblurred through blind deconvolution without estimation method.

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