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Blur Parametric Estimation on Natural Images for Linear Motion, Out-Of-Focus and Gaussian Blur for Blind Restoration

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Abstract: Image restoration and recognition in blurred and poorly illuminated images is difficult. The recognition and the restoration factors are of vital importance in this endeavour. Image blur is difficult to avoid in many situations and can often ruin a photograph. Image deblurring is a process, which is used to make pictures sharp and useful by using mathematical model. The blind image restoration used to remove the blurs in the image. In this, the modified radon transform used to handle the three types of blurs in the given input image. The proposed method is used for estimating the parameters of linear motion, out-of-focus and gaussian blurs. The method is implemented by analyzing the blurred images spectrum. The modification in the radon transform is proposed in this. Blur parameters are identified using these modifications of radon transform i.e. radon-d, radon-c transform. By fitting an third order polynomial function that accounts separately for the image spectrum and the blur frequency blur parameters are estimated.

Keywords: Gaussian blur, linear motion blur, Image restoration, Out-of-focus, Radon transform, Radon-d, Radon-c, Spectrum of blurred images.

I. INTRODUCTION

Images are captured in various areas ranging from day to day photography to remote sensing, scientific and biological fields. Unfortunately all images end up more or less blurry. This is due to the fact that there is a lot of interference in the environment as well as in the camera. The blurring or degradation of an image can be caused by many factors such as movement during the capture process, using long exposure times, using wide angle lens etc. Image deblurring is used to make pictures sharp and useful by using mathematical model. High dynamic range (HDR) more popular in recent years. HDR cameras are available for photography but they are expensive and not user friendly. Blur can occur when images are captured using cameras that are hand held due to camera shake and long exposures.

A method for image deblurring is proposed. A blurred image can be considered as a convolution function of a sharp image and a blur kernel or PSF. So in order to retrieve the sharp image it has to be split the image into its blur kernel and sharp image. But the problem here is the estimation of the blur kernel. This unknown blur kernel estimation is known as the blind deconvolution. Most of the deblurring techniques make use of these concepts. If the blur kernel is known in prior then it is nonblind deconvolution.

II. SYSTEM DESCRIPTION

The proposed method can handle the three types of blurs: linear motion, out-of-focus blur and guassian blur. This method is used to estimate the clear image. The modified radon transform is used to estimate the parameters of the blurred image. The radon-d transform is used for handling linear motion blur and gaussian blur. The radon-c transform is used for handling out-of-focus blur. Image deconvolution/deblurring, the goal is to estimate an original image f from an observed image g, assumed to have been produced according to

$$g = f * h + n$$

Where h is the blur kernel (PSF), n is a set of independent samples of zero-mean Gaussian noise of variance σ, and denotes the two-dimensional (2D) convolution. In standard deconvolution, it is assumed that h is known. In blind image deconvolution (BID), one seeks an estimate of the image f, where the knowledge about blur kernel is partially or totally unknown about the blurring operator h. BID is clearly harder than its nonblind counterpart; the problem becomes ill-posed both with respect to the unknown image and the blur operator.

There are two main alternative approaches to BID:

1. Simultaneously estimate the image and the blur;
2. Obtain a blur estimate from the observed image and then use it in a non-blind deblurring algorithm

Many of those methods follow the strategy of alternating between estimating the blur kernel and the image. To do so, prior knowledge about the image and the blur are usually formalized, under a Bayesian or a regularization framework. Most of the methods are using type(1) method. In the proposed system blur estimation technique used is approach of type (2).

The proposed method does not require any prior knowledge of any kind of parameter, and it is in this sense a truly blind method. The only assumption made is that the blur results from linear motion or out-of-focus or Gaussian

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blur. The proposed method to estimate the parameters for two standard classes of blurs: linear uniform motion blur and out-of-focus. These classes of blurs are characterized by having well defined patterns of zeros in the spectral domain. This works on the spectrum of the blurred images, and is supported on the weak assumption that the underlying images satisfy the following natural image property: the power-spectrum is approximately isotropic and has power-law decay with respect to the distance to the origin of the spatial frequency plane. This improve upon our existing methods in several ways. A new parametric model, combined with two modified Radon transforms, which includes two terms: one that approximates the image spectrum and another one approximating the blur spectrum (a sinc-like function, in the motion blur case, and a Bessel function in the out of focus case).Although this method is parametric, it has several advantages. Firstly, it relies on a weak assumption, which is valid for most natural images: the power-spectrum is approximately isotropic and has a power-law decay with respect to spatial frequency. Secondly, it is faster than statistical methods, as it does not use any iterations, and scales well with the image size (the most expensive operation is a single global FFT).

A. Linear Motion Blur

Linear motion blur means the linear movement of the entire image, along one direction the linear motion blur estimation will be done in two phases: (i) angle estimation; (ii) motion length estimation. The angle estimate is that for which the maximum of the Radon Transform occurs; naturally, this only works for very long blurs, so that the blurred image is very smooth in the motion blur direction, leading to a clear maximum of the RT. In continuous domain, the angle depends on direction of motion and length depends on the speed and duration of exposure. In discrete domain both the angle and length depends on time spent to recover the image. It changes the integration limits of the Radon transform, and show that this change improves the angle and length estimation accuracy: the quasi-isotropic power spectrum of natural images allow using the same parametric model independently of the motion angle.

B. Out-of-Focus

Out-of-focus blurring occurs if the camera is not properly focused, thus the focal plane is away from the sensor plane. In this case, a single bright spot spreads among its neighbouring pixels, yielding a uniform disk. The more unfocused the image is, the larger the radius of this disk. Different depths maps yield disks with different sizes; thus, assume that the focal distance is at infinity. This assumption works reasonably well for the majority of natural images where the scene is far away from the camera. The Radon-c modification of the RT performs integral over the circular area. This transform takes the value of the logarithm of the spectrum magnitude of the natural image. For out-of-focus blurs, the zero patterns of the corresponding Bessel functions in the Fourier domain are circular; to capture this behaviour, making use of a circular Radon transform, had not been used before in the context of blur estimation. These new features allow accurately estimating longer blurs with sub-pixel precision. In this case, a blur is characterized by only one parameter: its radius R.

C. Gaussian Blur

Gaussian blurs (also known as Gaussian smoothing). The blurring technique has visual effect of a smooth blur which is similar to that of viewing the image through a translucent screen, which is entirely different from the effects produced by an out-of-focus lens or the object shadow under normal illumination. Gaussian blur is mathematically applying Gaussian blur to an true image is equvalent to convolving the image with a Gaussian function. This type is generally used to model a variety of devices such as cameras and optical scopes. In remote sensing and aerial imaging applications, blurs are caused by several factors such as temperature and wind speed among others. For long-term atmospheric exposure, the Gaussian model is usually used. As a result, the term atmospheric turbulence blur is also used in some literatures.

D. Parameter Estimation

Radon Transform

The first module in this project is radon transform. Applying the Radon transform in an image for a given set of angles used to computing the projection of the image along the given angles. The sum of the intensities of the pixels in each direction and a line integral is the resulting projection. The radon transform can be written mathematically by defining,

$$\Phi = -x\cos\theta - y\sin\theta \qquad (1)$$

The Radon transform (RT) is an integral transform that consists of the integral of a function along straight lines. Formally, the RT of a real-valued function Φ(x,y) defined on R^2, at angle θ, and distance ρ from the origin, is given by

$$\Re(\phi,\rho,\theta)=\int_{\infty}^{\infty}\int_{\infty}^{\infty}\phi(x,y)\delta(\phi - x cos\theta - y sin\theta)dxdy \qquad (2)$$

The result obtained using the built-in MATLAB Radon tranform. The Radon transform is a mapping from the rectangular coordinates (x,y) of cartisian to a distance and an angel (ρ,θ), also known as polar coordinates.

Modified Radon Transform

The modifications in the radon transform are called as modified radon transform [1]. The modification is integration of an image along different angles and length. The integration of an image along circles with radius Φ performs integration directly in polar coordinates.

In proposed method, this introduce two modifications to the RT. Natural images have an approximate coarse behavior of log|G(ξ,η)| along lines that pass through the origin, independently of the angle. In proposed method it captures this behaviour in two different ways:

1. Performing the Radon Transform with the same integration area for different angles
2. Integrating along circles, rather than parallel straight lines

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Radon-d Transform

The Radon-d is the modification of RT work independently of the direction of integration and integration over the same area. This is achieved by computing the RT of the whole image changing the integration limits to contain only the maximum inscribed square.

$$R_d(\Phi;\rho;\theta) = \int^d_d f(\Phi\cos\theta - s\sin\theta, \Phi\sin\theta + s\cos\theta)ds \quad (3)$$

To approximate the Radon-d transform of a natural image fitting a third order polynomial

$$R_d(\log|F|, \rho) \approx a\rho^3 + b\rho^2 + c\rho + d \quad (4)$$

Radon-c Transform

The Radon-c modification [1] of the RT performs integral over the circular area. This transform takes the value of the logarithm of the spectrum magnitude of the natural image. Limiting the integration interval is not the only way to capture the quasi invariant angular behavior of log|G(ξ,η)|. Instead, it may integrate along circles with radius ρ perform integration directly in polar coordinates,

$$\mathcal{R}_c(f,\rho) = \frac{1}{2\pi\rho}\int_{-\pi}^{\pi} f(\rho\cos\theta, \rho\sin\theta)\,d\theta \quad (5)$$

For better approximation,

$$\mathcal{R}_c(\log|F|,\rho) \simeq \begin{cases} a|\rho|^b, & \rho \le \rho_0 \\ d|\rho|^c + e, & \rho > \rho_0 \end{cases} \quad (6)$$

where $d = \frac{ab}{c}\rho_0{}^{b-c}$ and $e = a\rho_0{}^b - d\rho_0{}^c$ since the approximate function must be continous at $\rho = \rho_0$.

E. Proposed Method

The proposed algorithm to infer the parameters of linear uniform motion blurs and out-of-focus blurs. For the linear uniform motion case, the parameters to estimate are the angle and the length. In the out-of-focus case, the only parameter is the radius. A new method to estimate the parameters for two standard classes of blurs: linear uniform motion blur and out-of-focus. These classes of blurs are characterized by having well defined patterns of zeros in the spectral domain.

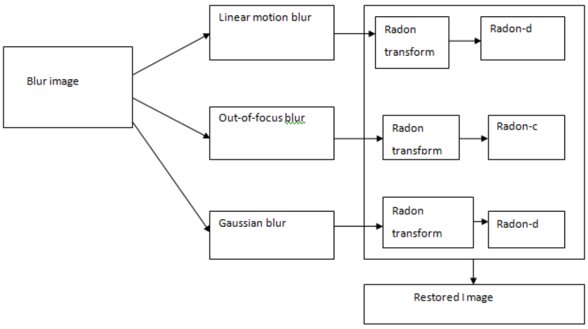

Figure 1: Proposed Method

Fig.1 A sample line graph using colors which contrast well both on screen and on a black-and-white hardcopy

The method proposed works on the spectrum of the blurred images, and is supported on the weak assumption that the underlying images satisfy the following natural image property: the power-spectrum is approximately isotropic and has power-law decay with respect to the distance to the origin of the spatial frequency plane. To identify the patterns of linear motion blur and out-of-focus blur, we introduced two modifications to the Radon transform, termed Radon-d and Radon-c. The former is characterized by performing integration over the same area of the image spectrum, while the later performs integration along circles. The identification of the blur parameters is made by fitting appropriate functions that account separately for the natural image spectrum and the blur spectrum. The accuracy of the proposed method was validated by simulations, and its effectiveness was assessed by testing the algorithm on real blurred natural images. The restored images were also compared with those produced by state-of-the-art methods for blind image deconvolution.

F. Results and discussions

Power Spectrums

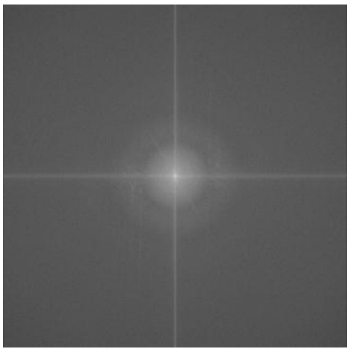

Figure 2: Power Spectrum of Out-of-focus

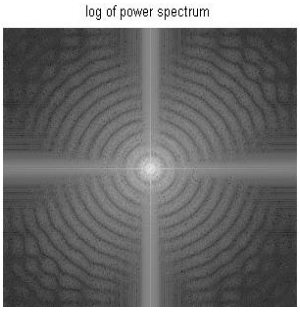

Figure 3: Power Spectrum of Gaussian Blur

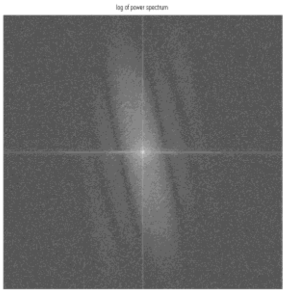

Figure 4: Power Spectrum of Linear Motion Blur

Estimated kernels of three types of blurs

Figure 5: Kernel- Linear Motion

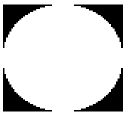

Figure 6: Kernel - Out-of –Focus Blur

Figure 7: Kernel – Gaussian Blur Performance Analysis

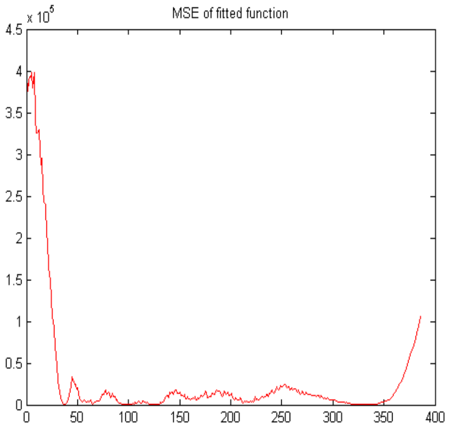

Figure 8: MSE of Fitted Function for Linear Moion

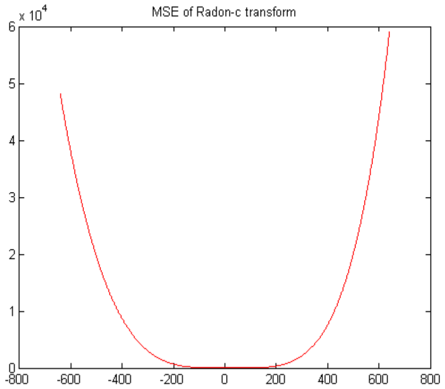

Figure 9: MSE of Fitted Function for Out-Of-Focus

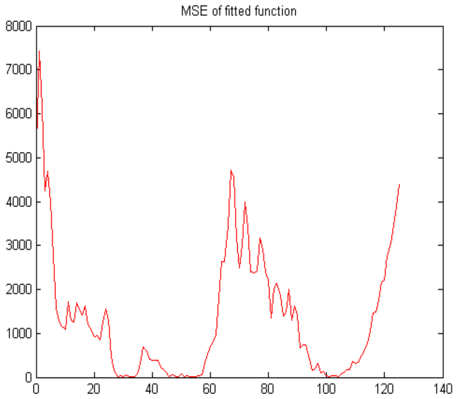

Figure 10: MSE of Fitted Function for Gaussian Blur

III.CONCLUSION

The proposed method is to estimate the parameters for three standard classes of blurs: linear uniform motion blur,out-of-focus and gaussian blur. These classes of blurs are characterized by having well defined patterns of zeros in the spectral domain. To identify the patterns of these types of blur, introduced two modifications to the Radon transform, i.e. Radon-d and Radon-c. The method is used to estimate and minimize the parameters values of the blurred image and restore the blur image to its original clear image The accuracy of the proposed method was validated by increasing the value of PSNR metrics. This modified radon transform is very fast and accurate. By implementing this algorithm, loss of information can be rectified. This can be used in biometrics applications where the images are blurred due to shaking of hand and variation in shutter speed.

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