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Quality Improvements of Camera Captured Pictures using Blind and Non-blind Deconvolution Algorithms

Pallavi U. Patil, Sudhir B. Lande, Vinay J. Nagalkar, Sonal B. Nikam

Abstract: ***Camera captured image is a set of three-dimensional picture frame. This picture frame is a set of different characteristics and parameters. Captured picture suffers from image blurring parameters. These blurring parameters are created by camera misfocus, motion, atmospheric causes, camera sensor noise etc. Thus, captured picture is represents the blurry image format due to lot of interferences occurs in the surrounding background and picture captured device. Hence, some information is corrupted i.e. degradation occurs in the camera captured picture. Therefore, it needs to reconstruct the original picture using image restoration process. Restoration operation includes different image deblurring algorithms such as Non-blind deconvolution and Blind deconvolution algorithms. Non-blind deconvolution algorithms are more effective when blurring parameters of captured picture is known but Blind deconvolution algorithm recover the blurry image without prior knowledge about blurring parameters.***

Keywords: Additive Noise, Blur Detection, Blurred Operator, Convolution, Deconvolution, Image Restoration.

I. INTRODUCTION

Captured picture is the combination of different parameters or characteristics. Sometimes the captured image is may be corrupted because the information of original image is lost that means captured image is blur. Hence, captured image represents a noisy version of original object.

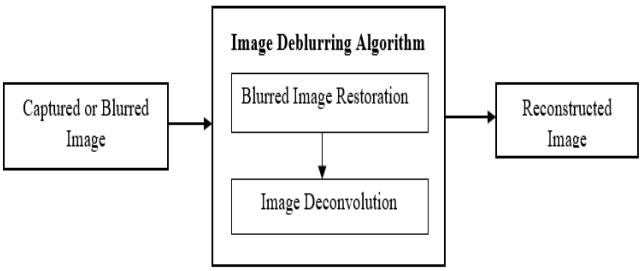

Fig 1. Block Representation of Image Deblurring Process

In improper image formation process blurring also represents the contrast reduction of the captured picture. When camera captures an image at that time blurring can be occurred by above reasons,

1.1 Average Blur

The average blur is the group of various parameters which are helps to remove a noise present in an image. The average blur parameters work when blur function is present over the whole entire image. Average blur can be circulated in Parallel and Perpendicular plans. These plans represent Horizontal and Vertical directions of the captured image. This type of blurring can be spread using circle radius r . Radius r calculated by using formula,

$$r^2 = x^2 + y^2$$

Where,

x = Direction of Horizontal Blur

y = Direction of Vertical Blur

r = Circle Radius

1.2 Motion Blur

Motion blur function of image created because of camera mis-focus, distance between camera and object. Using motion effect filter in an image can be evaluated motion blur effect. This filter is used only when camera is captured objects relative motion during exposure time (capture time) that means, motion blur parameter is entire in captured image due to particular direction. The motion parameter can be stabilized by using 0 to 360 angles and directions.

1.3 Gaussian Blur

Gaussian noise function is related to the pixel weights and kernel of the captured image. In this blurring process the pixel weights are not equal. These weights are reduced from kernel canter to bell-shaped curve edges. Using Gaussian blur effect, a specific number of pixels are merged incrementally. Based on the blurred operator the restoration algorithms are divided into two algorithms or techniques such as non-blind deconvolution and blind deconvolution algorithms. These algorithms are also known as Image deblurring algorithms.

II. LITERATURE SURVEY

This section presents a literature survey. The following table presents different techniques or algorithms to improve image quality. Also, it shows the advantages and results of different algorithms.

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Table-I: Review on state-of-the-art of image deblurring algorithms

Paper Title	Published Year	Deblurring Technique	Result
Evaluation of Image Deblurring Techniques.[1]	2016	Wiener filter, Lucy-Richardson method, Regularized filter, Motion density, Neural networks, Blind deconvolution.	The Non-blind deconvolution algorithms need the previous information about the blur functions. The PSNR value of Non-blind deconvolution algorithms are Low. Blind deconvolution algorithm works on unknown blurring parameters. It's PSNR value is greater than Non-blind deconvolution algorithms hence, this technique gives best result as compare to Non-blind deconvolution Technique.
A Comparative Analysis of Image Deblurring Using Deconvolution.[2]	2016	Wiener Filter, Blind deconvolution.	Wiener filter algorithm requires the prior knowledge about the PSF for its operation. When PSF value changes because of human then this algorithm gives faulty output.
An Analysis on Implementation of Various Deblurring Techniques in Image Processing.[3]	2016	Blind deconvolution, Non-blind deconvolution.	In Non-blind deconvolution algorithms, wiener filter gives low performance it's PSNR value is very less as compare to other Non-blind deconvolution techniques.
Survey Paper Analysis on Deblur Image Using Various Deblurring Technique Method.[4]	2017	Subspace Analysis, Removing blur with Image statistics, Blur estimation, Deblurring with noisy image pairs.	Blur detection method is recovering the blurred area of an image. This blur is generated because of defocus of image captured device or motion of an image. After deblurring we gives the value of PSNR and MSE parameters. The value of PSNR parameter gives information about image quality. The value of PSNR must be high.
Image Deblurring.[5]	2017	Lucy-Richardson algorithm and Blind deconvolution algorithm.	The quality of image depends on the PSNR value. Lucy-Richardson algorithm gives better result of SNR value when the prior knowledge about noise and blur function but Blind deconvolution algorithm gives good result of Image which gives higher value of PSNR with unknown noise and PSF.
Comparative Analysis of Different Deblurring Techniques.[6]	2018	Blind image deconvolution, Deblurring with – Blur estimation, Noisy image pairs, Linear ternary pattern and Image statistics.	The subspace analysis finds out the different blur textures but does not solve the problem of uniform textures present in that image. Blind image deconvolution is more reliable because it finds out unknown blurring textures in that image.
Image Deblurring Techniques – A Detail Review.[7]	2018	Blur region detection and Classification, Kernel estimation, Blind deconvolution, Non-blind deconvolution.	Non-blind deconvolution algorithm represents three types –Wiener filtering, Richardson-Lucy algorithm and Regularized filter. Wiener filter gives the best result when Gaussian noise present in the image. Richardson-Lucy gives better result with higher value of PSNR parameter but it generates number of iterations therefore ringing artifacts created. Blind deconvolution algorithm removes the point spread function effect and recover image without previous information about PSF, types of blur and noise present in that image. This technique provides the better resultant image as compared to Non-blind deconvolution methods.
Deblurring of Shaken Images – A Comparative Study of Various Algorithms.[8]	2018	Non-blind deconvolution methods and Blind deconvolution.	The Blind deconvolution algorithm produced good result with and without knowledge of noise in terms of PSNR and MSF as comparative to Non-blind deconvolution algorithms.

A Review on Image Restoration and Its Various Blind Image Deblurring Algorithms.[9]	2019	Image restoration methods.	Image deblurring algorithm uses restoration function for better image quality. Using image restoration algorithm is to de-blur the degraded image on prior knowledge of PSF and noise for good restoration process.
Performance Research on Iterative Methods for Image Deblurring.[10]	2019	Inverse filter, Least square filter, Constrained least square filters, Spatially adaptive algorithm, Blind deconvolution.	The Inverse filter, Least square filter. Constrained least square filters and Spatially adaptive algorithms are uses number of iterations which are based on known blurring parameters and noise present in that image. These number of iterations reduces the speed on operation. Blind deconvolution method works on known and unknown blurring parameters and noise which uses less number of iterations and increase speed of operation.

2.1 Problem Statement

Camera captured picture is a combination of different characteristic. Sometimes capture picture is less or blurrier because of image blurring parameters. These blurring parameters are created by camera mis-focus or motion, atmospheric causes, camera sensor noise etc. Therefore, some information of captured image is corrupted.

III. IMAGE DEGRADATION AND RESTORATION MODEL

Sometimes captured image result is blur image i.e. degradation is due to recorded image. Using image restoration process quality of corrupted or noisy image is increases.

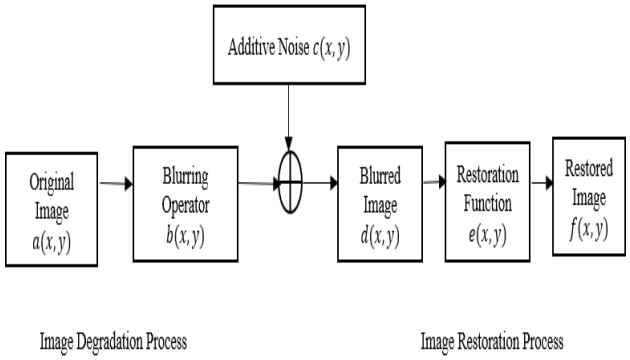

Fig 2. Block Presentation of Noisy Image Restoration Process

Where,

$a\ (x,y)$ = Original Image before Degradation
$b\ (x,y)$ = Blurring Operator (Point Spread Function)
$c\ (x,y)$ = Additive Noise
$d\ (x,y)$ = Blurred Image
$e\ (x,y)$ = Restoration Function
$f\ (x,y)$ = Restored Image

Therefore,

$$d\ (x,y)\ =\ a\ (x,y)\ *\ b\ (x,y)\ +\ c\ (x,y) \qquad (1)$$

Here,

* indicates convolution representation.

Now, equation (1) shows that the original image $a(x,y)$ gets convolved with the Blurring operator $b(x,y)$ and additive noise $c(x,y)$ is added to it. This process is called as Image degradation process. Therefore, deconvolution is applied to the Blurred image which removes the blurring function present in an image.

IV. CONVOLUTION

Convolution is a mathematical process which gives modified version of two original functions. In this section original image $a(x,y)$ and degradation function $b(x,y)$ producing a third function. $a * b$ is represent the convolution operation of $a(x,y)$ and $b(x,y)$ .This function defined as the integral product from of original image and degradation function that means two functions are reversed and shifted by one. The equation of these two functions are written as,

$$(a * b)(t) \stackrel{def}{=} \int_{-\infty}^{\infty} a(\tau)\ b(t-\tau)d\tau \qquad (2)$$

OR

$$(a * b)(t) \stackrel{def}{=} \int_{-\infty}^{\infty} a(t-\tau)\ b(\tau)\ d\tau \qquad (3)$$

Here,

t Symbol represents the convolution formula can be described as a weighted average of the function $a\ (\tau)$ at the moment t .Now, the weighting is given by $b\ (-\tau)$is shifted by amount t, as t changes the weighting function changes their effect to different parts of the input function. The convolution function a and b uses $[0,\infty]$ i. e zero represents negative value of parameter. Therefore, the integration limits changes form o to t.The resulting integration of this function can be written as,

$$(a * b\ ) = \int_0^t fa(\tau\ )b\ (t-\tau)\ d\tau \qquad (4)$$

V. BLURRED OPERATOR

Point Spread Function (PSF) is the blurring operator. The PSF variations depend on the Object, Image Capturing device or Camera and Distance between object and camera (Wavelength). The quality of camera captured picture measures with the help of point object by using its degree of Point Spread Function.

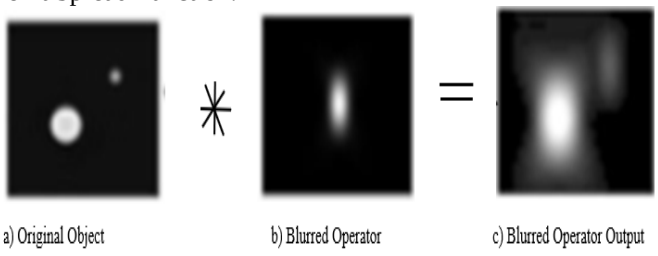

Fig 3. Image Formation with a Blurred Operator (PSF)

Therefore,

$$f(x,y) = a(x,y) * b(x,y) + c(x,y) \quad (5)$$

Where,

$f(x,y)$ = Noisy Image
$a(x,y)$ = Original Image
$b(x,y)$ = Blurring Operator (PSF)
$c(x,y)$ = Noise

VI. IMAGE DEBLURRING ALGORITHMS

6.1 Non- Blind Deconvolution Algorithm

This image deconvolution algorithm is recovering the blurry-noisy image when it's known prior knowledge about the blur kernel. There are three types of methods included in the Non-Blind deconvolution algorithm.

6.1.1 Image Deblurring Using Wiener Filter

Wiener filter deconvolution algorithm works on previous information about blurred operator i.e. Point Spread Function (PSF), frequency characteristics of the image and additive noise are present in an image i.e. This technique is more effective in the presence of both parameters such as blur and noise. With the help of linear time-variant filter the Wiener filter produces estimated desired random process for denoising the captured image.

6.1.2 Image Deblurring Using Regularized Filter

Regularized filter image deblurring algorithm is one of the types of Non-Bind deconvolution algorithm or technique. Regularized filter is requiring less information about the Additive noise. This filter is can be used to Smoothness operation is applied in the Blur image or Recovered image. Using Least Mean Square restoration algorithm in the Regularized filter operation the blurring function and noisy image parameters are restored.

6.1.3 Image Deblurring Using Lucy-Richardson

The Lucy-Richardson algorithm is works on the blurred image without prior information about additive noise but is require the prior information about Blurring operator i.e. Point Spread Function (PSF). Using Iterative method, it restored noise function. The Iterative algorithm works on known PSF and restored the blurred image which is blurred by PSF.

6.2 Blind Deconvolution Algorithm

Blind deconvolution algorithm works on the unknown blurring operator and additive noise. Hence Blind deconvolution algorithm works on the corrupted image which does not contain any previous information about the blurred operator (PSF) and noise present in the captured image. With the help of Iterative algorithm in the Blind deconvolution operation we get information about the unknown PSF and increases the quality of camera captured image. This algorithm uses less number of iterations in the image restoration process. Therefore, result of Blind deconvolution algorithm is highly effective than Non-Blind deconvolution algorithm.

VII. RESULT

a) Original Image

b) Captured Image

c) Output of Wiener Filter

d) Output of Regularized Filter

e) Output of Lucy-Richardson Algorithm

f) Output of Blind Deconvolution Algorithm

Fig 4. Effects of Image Deblurring Algorithms

Figure (4) repesents the different effects of image deconvolution algorithms which are reconctrut the blurry camera captured image.Figure (b) shows the camera captured image,it losses some information as campare to original image (figure-a) because of camera misfocus or atmospheric causes etc. Therefore, image deblurring algorithms are applied on this blurry captured image. Wiener filter algorithm works on only known blurring parameters such as PSF, Additive noise or Camera sensor noise therefore, result of these algorithms is less effective as shown in figure (c). Regularized filter algorithm required minimum information about blurring parameters hence, the output image of this technique is not effective but good as compare to Wiener filter algorithm as shown in figure (d). Lucy-Richardson algorithm based on known PSF but unknown Noise hence number of iterations are used therefore output of this algorithm is not more effective but good as compare to Wiener filter and Regularized filter algorithms as shown in figure (e).Blind deconvolution algorithm recovers the blurry image without previous information of blurred operator and noise present in a captured picture hence, less number of iterations are used therefore, this algorithm is reconstructing the blurry image more effectively as compare to Wiener filter, Regularized filter and Lucy-Richardson algorithms as shown in the figure (f).

Table II. Comparison between image deblurring algorithms

Sr. No.	Algorithm	Type of Blur	Blurred Operator	Noise	Number of Iterations	Effectiveness
1)	Wiener Filter	Motion blur, Gaussian blur	Known	Known	Not Used	Bad
2)	Regularized filter	Motion blur, Gaussian blur	Require Minimum Information		Not Used	Good
3)	Lucy-Richardson	Motion blur, Gaussian blur	Known	Unknown	More	Effective
4)	Blind Deconvolution	Motion blur, Gaussian blur, Average blur	Unknown	Unknown	Less	More Effective

VIII. CONCLUSION

The non-blind deconvolution algorithms are effective than the previous information of blurring operator and noise present in an image are known. Only one of the types of non-blind deconvolution algorithm is Lucy-Richardson is works on unknown noise function using a greater number of iterations. The blind deconvolution algorithm is more effective than Non-blind deconvolution algorithms because of it is used to deblur the noisy image (blurred image) without previous information of blurred operator and additive noise present in the captured picture. It reduces the number of iterations required for denoising the image for reconstructing the captured image hence deblurring speed of algorithm increases. Blind deconvolution method is gives best result as compare to non-blind deconvolution techniques.

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