RESTORATION OF BLUR AND NOISY IMAGES USING DEMPSTER-BELIEF PROBABILISTIC APPROXIMATION

Deepa Bamne*

Ramratan Ahirwal**

Yogendra Kumar Jain***

ABSTRACT:-

Digital images are very widely used for many scientific and forensic investigations but the quality of digital image snapshots may be degraded. Digital snapshots may gets blur due to bad focus of camera, relative motion between the scene to be capture and camera etc. This work proposes a probabilistic approach to recover these images in order to improve the quality of degraded image. A Dempster-Belief probabilistic approximation is used to approximate the blur distribution (PSF). Wiener filter uses this approximated PSF in order to get the noiseless and unblur image. Also padding is done to recover the image after proper blur approximation. This work also makes use of Haar wavelet transform. The proposed method gives the better result from the previous method. It seems to be that the PSF and Mean Square Rate is better in the proposed work.

Keywords:- Dempster-Belief theory, DWT, Haar transform, Wiener filter, PSF.

* Research Scholar, Samrat Ashok Technological Institute, Vidisha (M.P.), India

** Assistant professor, Samrat Ashok Technological Institute, Vidisha (M.P.), India

*** Head of the Department (CSE), Samrat Ashok Technological Institute, Vidisha (M.P.), India

I. Introduction

Image restoring is a mechanism to refine the original image from blur and noisy effected image. Motion blur occur due to relative motion between the camera and the object being imaged during an spotlight time. Basically in a scene, when the momentums of moving articles exceed the chronological resolution of the camera, then because of its technical limitation CCD camera lead to generate degraded picture affected by motion blurs.

Depend on photo capturing technique; image degradation origin by motion blur can be categorized namely as space-invariant and space-variant distortion [1]. Degree of space invariant distortion depends upon speed of camera while capturing spot where as position of camera don't play any role in space invariant distortion. Recently numerous research been carried out for image restoration for space invariant blur image. The main goal is to apply deconvolution technique [1-4] followed by evaluation point spread function (PSF) of the blurring system in order to restore original image from blur image. In space-variant motion blur distortion degree of distortion depend upon relative position of camera, the PSF, which causes the degradation, is a function of position in the image which generally shows in an image containing rapid-moving articles with different motions recorded by a static CCD camera.

The main objective of any image restoration technique is to reconstruct or estimate the undistorted image by using the corrupted version of the similar image. Usually, an image can be damaged by motion blur and noise. Relationship between the examined image E(x,y) and its undistorted version of image UD(x,y)[5,6] is shows in Eq. (1)

$$E(x,y) = UD(x,y) * PSF(x,y) + N(x,y) \ldots\ldots\ldots\ldots\ldots 1$$

Where PSF is the blurring function or point spread function that convolves with an original image and $N(x,y)$ is the additive noise function.

Image restoration algorithms suppose that only the observed image is available and no extra information about other parameters exists. According to Eq. (1), in order to determine the uncorrupted image, we need to find the blurring function PSF(x,y). Hence, in image restoration one of the major problem is to find an exact estimation of PSF(x,y). This process is called blur identification which is an ill-posed problem.

After knowing the degraded images, the paper focused again on Image restoration. Mainly two types of image restoration methods has been used widely that are Blind Image Deconvolution and non-Blind Image Deconvolution. In Blind Image Deconvolution, the image is restore without the prior knowledge of Blurring function i.e. PSF. In this class the PSF is to be estimated on the basis of observed image. While on the second class of Image Restoration i.e. non-Blind Image Deconvolution PSF should be known. Blind Deconvolution gives good results of restoring image as compared to non-Blind but the former has a disadvantage of large computation time required for iterations used to estimate the PSF. The later has no such disadvantage. The Proposed work is based on Blind Image Deconvolution in which we calculate PSF.

II. Related Work

A number of techniques for blur detection have been proposed recently by various researchers. Discrete wavelet transform (DWT) method is one of most efficient edges detection technique than other edge detection techniques. Wavelet transform calculate coefficient value of horizontal, vertical and diagonal scale for edges detection [2]. Tong et al. [3] present a method that employ Haar wavelet transform (HWT) in discerning different kinds of edges in addition to recovering sharpness from the blurred version, in order to verifies blurriness of an image and it degree of blurred. Ratnakar et al. [4] proposed an technique to approximate the motion blur parameters by employed Gabor filter for blur direction and apply radial basis function neural network for estimating blur length with sum of Fourier coefficients. Yang et al. [5] present a classification based motion blur detection scheme which is based on support vector machine (SVM) to classify the digital image as blurred or sharp. Chen et al. [6] use information of the natural sights and exploit multi-resolution decomposition technique to mine motion blur features to train and test probabilistic support vector machine.

In Cepstrum field, motion blur can be detached from blurred image. Cannon's method [1] present Cepstrum domain method for estimating of motion blur parameters. Krahmer et al. [7] apply Radon transform for evaluating feature of motion blur in cepstral analysis. Lokhande et al. [8] approximate motion blur parameter by evaluating periodic patterns in frequency spectrum. They use Hough transform and blur length evaluation by breaking up the 2-D spectrum into 1-D spectrum. Fang et al. [9] discuses a method having an pre-processing step which use Hann windowing and histogram equalization .where Hann windowing is responsible to remove boundary artifacts and histogram equalization is employ to improve the contrast of the image. Rekleities [10] employ steerable filter to identify the motion blur angle belongs to gradients having maximum response. Chang et al. [6] present a method that use bispectrum technique to detect motion blur parameters. In reference to their research they gives a conclusion that bispectrum is more invariant to noise in comparison to cepstral. Efficient techniques for motion blur detection that use Discrete Cosine Transform (DCT) of image is presented by Yoshida et al. [11]. Shamik et al. [12] discussed different approaches for motion blur detection and estimation.

Along with that recently numerous of research has been carried out for deblurring the blur and degraded image into original image. Some technique like Wiener filter [13], Fourier wavelet regularized deconvolution [14], Expectation–Maximization algorithm for wavelet-based image deconvolution [15] is being recently use and having apriori information regarding the temperament of the degradation function. Generally in some practical conditions, degradation function h(x,y) is not to be known. Which lead difficulty in restoration course to recover the original image only on the basis of blur image which refer as blind deconvolution. In [16], Hough transform employed to identify the lines in the spectrum of the blurred image and subsequently, bispectrum help to conclude the blur parameters [17]. Authors in [18] present a adaptive Adaline network to approximate motion length of a degraded image which is a rough estimation of motion length and use in power spectrum. Igor Aizenberg et at. [19] present an technique to identify horizontal blur. Which is a comparable effort to aprior approximate the motion blur parameters (theta, L) from blur images and to rebuild the PSF for restoration.

Ratnakar Dash etal [20] deals with estimation of parameters for motion blurred images. The main objectives are to estimate the length (L) and the blur angle (θ) of the given degraded image as accurately as possible so that the restoration performance can be optimized. Gabor filter is utilized to estimate the blur angle whereas a trained radial basis function neural network (RBFNN) estimates the blur length. Once these parameters are estimated the conventional restoration is performed. In this paper they have proposed yet another deblurring scheme which is based on apriori blur parameter estimation from motion blurred images. Subsequently, the estimated PSF from the parameters obtained are utlised for conventional restoration. To estimate the angle of blur we use the Gabor filter whereas for length of blur we utlise a RBF neural network. Both the estimation schemes perform accurately even at the noisy conditions.

Zhao Peng etal [21] address the space-variant image restoration for interlaced scan images, a three-step image restoration scheme is proposed. Initially, one interlaced scan image is divided into odd field and even field images. Then, these two field images are further segmented into rectangular blocks and the motion vectors are computed based on these rectangular blocks using an efficient block matching algorithm. After that, image restoration is performed using a blind deconvolution algorithm in the odd or even field image. Then at the end restored image is obtained by combining the restored odd and even field images. The idea is illustrated by restoring a space-variant blurred moving vehicle image and a synthetic blurred image.

Deyi Ma [22] analyzes virtual and real motion blur consistence in augmented reality system, and mainly improves in two aspects, how to get the motion blur parameters, and how to render motion blur. It can be seen that, most achieved methods to get motion blur parameters are based on machine vision. But in this paper first acquires the motion trajectory by magnetic tracking, and then finds motion blur parameters. By Considering the available literature on motion blur rendering methods, they consists of convolution and accumulator caching and so on. Due to rotation translation compound motion blur, this paper does rendering in advance based on improved mathematical model, and then render virtual object through looking up table in augmented reality system. In this paper, virtual object and real object motion blur consistence is researched in detail in augmented reality system. The main ideas are as follows. Motion trajectory is real-time obtained by magnetic tracking , and then the parameter of motion blur is analyzed. For rendering, the effect of rotation translation motion blur is based on modified mathematics model, which is provided in this paper. The blur effect of real-time rendering is realized through looking up table in augmented reality system. The render algorithm, which is provided in this paper, can realize the virtual object and real object consistence. From the simulation environment and real scene, the new algorithm can obtain better result and low time complexity.

Even though there is a large volume of work related to motion blur reported in the literature, researchers are still active in this direction to improve the results in terms of visual quality and peak signal to noise ratio (PSNR).

III. Proposed Method

The main aim of presented paper is restoring the original image from blur and noisy effected image. Firstly we create noisy and blur image by using noise function and Gaussian blur kernel. After obtaining the noisy and blur image, we apply the Dempster belief probabilistic approximation for estimation of blur distribution, point spread function (PSF). This PSF works as the deblurring parameter in wiener filter to find the noise free and deblur image.

How to create noise: - To get the noisy image we add the noise in the original image by using salt and pepper noise function. Salt and pepper noise here is added to the image by taking a default noise density with the value d=0.05.

Algorithm for adding noise:

Algorithm:

Step 1: Take original image.

Step 2: Add salt and pepper noise to the original image with default noise density, d=0.05.

End

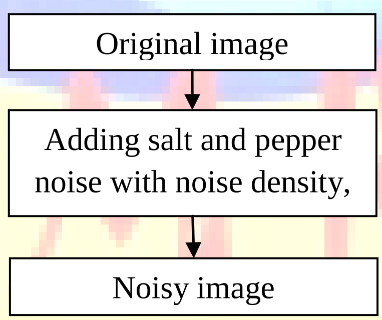


Figure 1:- Flow diagram showing the addition of noise in original image.

How to create blurring: - To create a blur image from the noisy image, we are required to create a kernel which is used to generate a blur in image. Kernel is a window in which we are required to choose the size of it. In our work we make using Gaussian blur kernel to blur the noisy image and the size of this kernel is used to maintain the degree of blur. Now let the size of a kernel for the proposed work is denoted by k_{size} and its value is 31. To choose the value of kernel we make use of a function which is called as Gaussian function. In this Gaussian function which use the variance on which the degree of blur depends, larger variance generate higher blur and lower variance generate smaller blur. For our work the variance is chosen. Let the variance be chosen be s and its value is 3, also let the Gaussian mean is selected in such a way that mean should just be in the center of kernel image. So, the mean for proposed blurring will be m= k_{size} /2. Finally the blur kernel is generated by using the inbuilt matlab function meshgrid function.

s = selected;

m = k_{size}/2;

[X, Y] = meshgrid(1:k_{size});

Kernel = (1/(2*pi*s^2))*exp(-((X-m)^2 + (Y-m)^2)/(2*s^2)); ………………………... 2

Where s denotes the variance, m denotes the mean, X and Y shows the distance from horizontal and vertical axis respectively.

Algorithm for Gaussian Blur Kernel Creation:

Algorithm:

Step 1: Choose the size of blur kernel ksize.

Step 2: Choose the Gaussian function variance s, where the degree of blur depends upon value of variance chosen.

Step 3: Calculate the value of mean, where m=k_{size}/2.

Step 4: Fill the value of blur kernel matrix with mesh grid() function with the equation for a two-dimensional Gaussian with mean m and variance s^2.

Step 5: Plot the blur kernel.

End

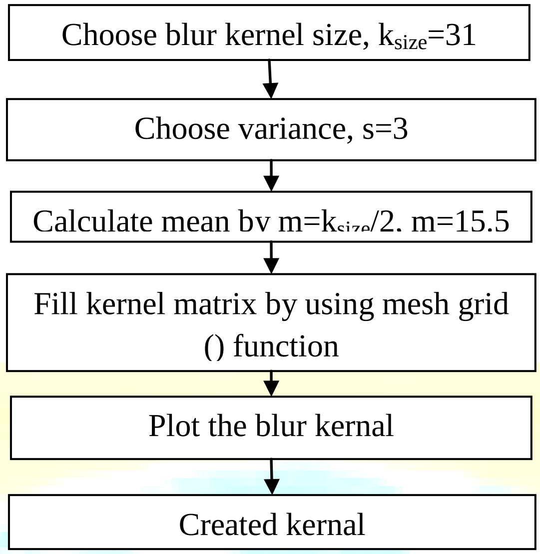


Figure 2:-Flow diagram showing phases in kernel creation.

1. Image degradation process: - To find the final noisy and blur image we apply discrete wavelet transform (DWT), Haar on noisy image which we have obtained from the original image. Also DWT Haar is applied on created kernel. And then the DWT's of the kernel image and noisy image are taken and are convolved. And as soon as the DWT's are convolved the image gets blur and noisy.

Algorithm for degradation process:

Algo (Degradation)

Step 1: Apply 2-D DWT (Haar wavelet transform) to the kernel image.

Step 2: Also apply 2-D DWT (Haar wavelet transform) to the noisy image.

Step 3: Multiply the 2-D DWT of kernel image and noisy image to get the blurred image.

End

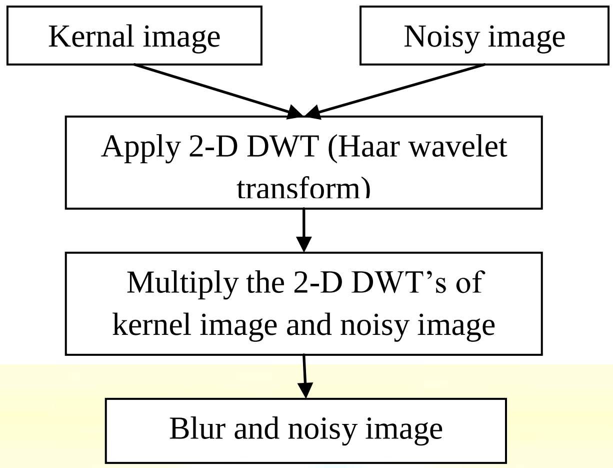


Figure 3:- Blur image creation

2. Image restoration process: -

In image restoration phase Dempster-Belief probabilistic approximation is applied to compute the degree of blur by using

$$p\left(R^{degraded}_{image}/k\right) = \prod_i q(q_{i,x}(x))q(q_{i,y}(x)) \prod_j q(y_j)$$

Where x and y shows the distance from horizontal and vertical axis respectively and k is approximate Gaussian Blur Kernel that has been added in degradation phase. Here Belief theory [23] is used to compute the probability of blur distribution which gives the PSF, let h be the value of PSF which is approximated.

Then Wiener filter is used for deblurring of blur image as we have already approximated the value of blur kernel (point-spread function). The Fourier transform of the deblurred image F is computed by:

$$F = (G/H) * (|H|^2 / (r+|H|^2))$$

where

G = Fourier transform of original blurry image

H = Fourier transform of blur kernel h

r = Deblurring parameter (r ≥ 0)

The value of deblurring parameter depends on the amount of noise we expect in the image. If the size of the image which is having noise is MxN with variance v, then r=MNv. But we don't know the variance of the noise so here it is estimated by using default value. If the image has no noise and is blur only, then value of r=0 [24]. Padding is applied on the degraded image with the size of the original image so that the effect of blurring could be minimized. Noise and blur are reduced with the help of Wiener filter after the padding is done. In this way both blur and noise degrades tends to reduce. In order to get the deblur image, next Inverse DWT is performed on the image.

Algorithm for restoration process:

Algo (Restoration)

Step 1:- Apply Dempster- Belief probabilistic approach for approximating the value of PSF.

Step 2:- Apply padding over degraded image.

Step 3:- Apply wiener filter for getting noiseless and deblurred image.

End

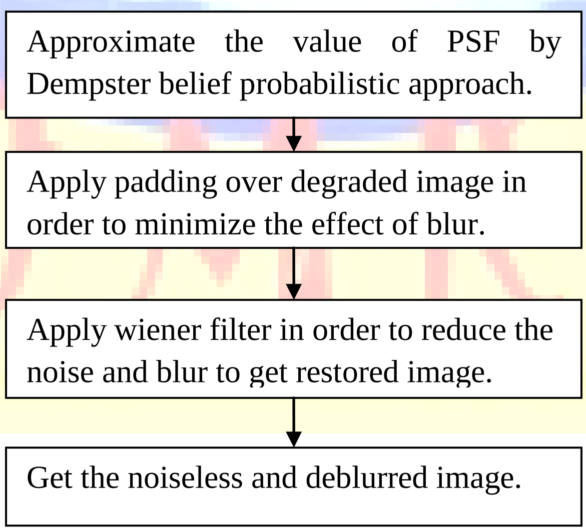


Figure 4:- Flow diagram showing various steps of restoration of image.

IV. Result Analysis

This work proposes the method for image restoration to restore the image that contains blur and noise There are four images taken as inputs namely BMW, PIC 1, PIC 2 and PIC3 and their dimensions are 256×256 pixels in jpeg format as show in figure 5.

a) BMW b) PIC 1 c) PIC 2 d) PIC3

Figure 5:- Input Data set

In result analysis we have taken normal photography image then performed a degradation process in which we have added noise to image pic3 as show in fig 5. For that Salt and pepper noise here is added to the image by taking a default noise density with the value d=0.05.This is followed by blurring of image which is done by applying DWT, through selected the value of variance as s=3 and as we have also selected k_{size}=31so, the value of m becomes 15.5. After that Gaussian mean is selected in such a way that mean should just be in the center of the kernel image and resultant generate blur image as show in figure 2 blur image. After that we have to take this blur image as our input and main focus of our work is to estimate blur, then as per proposed algorithms we have apply probability estimation to estimate the value of blur and Dempster-Belief method estimate the value of blur distribution (PSF). After the approximation of blur distribution kernal padding is done over blur and noisy image in order to minimize the effect of blur. Then wiener filter is applied to get noise free and deblurred image which uses the PSF that is approximated.

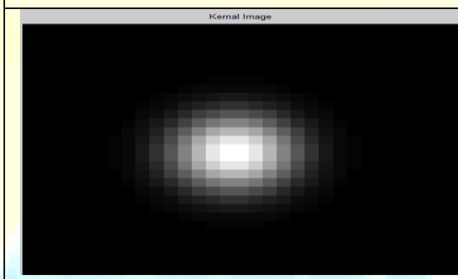
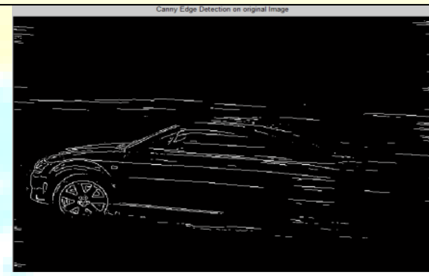
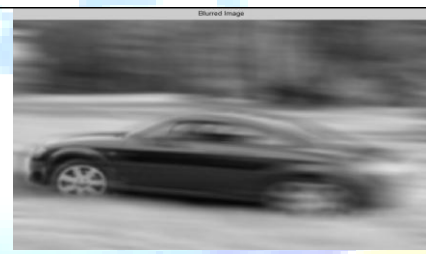
Proposed (Kernal Padding)	Previous (RBFNN)
 Original Image	 Deblurring with Undersized PSF
 Kernal Image	 Canny Edge Detection on original image
 Blurred and noisy Image	 Blurred Image
 Blur image with pad	 Blurred and Noise Image
 Unblurred image	 Deblurred Image

Figure 6:- Comparison of different phase of proposed method of restoration of blur and noisy image using Dempster-Belief probabilistic Approximation (Kernal Padding) and previous method of motion blur estimation for image restoration (RBFNN).

Then we are performing our test on an image which has partial sharp and blurred regions and apply kernel padding for de- blurring the input car3 image by IDWT and haar transform.

After reconstruction, for result comparison four different images has taken namely BMW, PIC 1, PIC 2 and PIC 3. Then, the proposed probabilistic kernel-padding algorithm is applied on these images and finds their final PSNR value as show in table1. The previous RBFNN algorithm for image restoration was performed with Gabor filter whereas for length of blur they utilize a RBF neural network . Their result and PSNR value also shows in figure 7 and table 1.

Table1: Comparison between PSNR ratio of proposed approach (Kernal Padding) and previous approach (RBFNN).

Image Name	Algorithm	PSNR (dB)
BMW.jpg	Kernal Padding	35.1576
	RBFNN	28.9645
PIC1	Kernal Padding	32.3658
	RBFNN	30.1307
PIC2	Kernal Padding	32.5781
	RBFNN	31.3595
PIC3	Kernal Padding	34.7205
	RBFNN	31.2589

PSNR is Factor of an image which is use to know the quality of the picture or image, it is calculated by using mean square error (MSE). The PSNR will be calculated between the original image and resulting image. Both parameters are calculated by the following formula

$$PSNR = 10\log_{10}\left(\frac{MAX^2}{MSE}\right) MSE = \frac{\sum_{M,N}[I_1(m,n) - I_2(m,n)]^2}{M * N}$$

The experimental results shows that the proposed algorithm gives the better performance with compared to previous approaches. The results are better for all the image data set. As shown in figure 7.

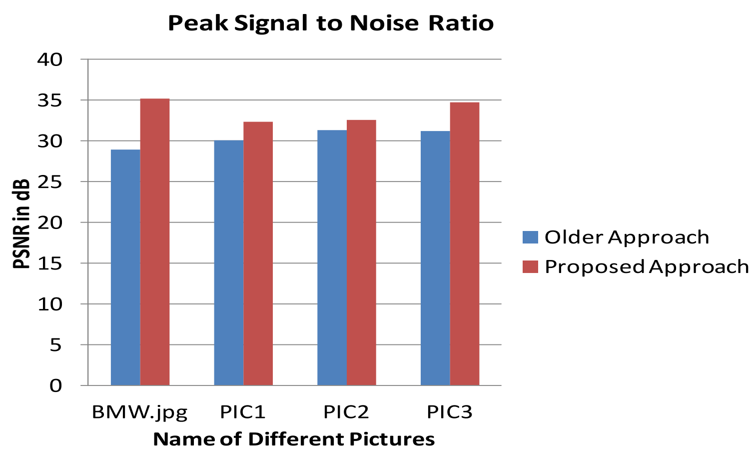


Figure 7:- Graph representing the difference in PSNR of older approach and proposed approach.

V. Conclusion

Degraded Image restoration is a procedure of restoring original non Blur and noise free image. In this work a probabilistic based Kernal padding Wiener filter technique for the restoration of images is proposed. The result parameter shows that the efficiency of the proposed technique is improved. The Error rate of the techniques is less as compared to the previous techniques. Also the blurry and noise effect can be effectively reduced using our proposed work.

References

[1] M. Cannon, "Blind deconvolution of spatially invariant image blurs with phase", IEEE Trans. Acoust. Speech Signal Processing, vol. 24, no. 1, pp. 56-63, 1976.

[2] M. M. Chang, A. M. Tekalp, and A. T. Erdem, "Blur identification uses the bispectrum", IEEE Trans. Signal Processing, vol. 39, no. 10, pp. 2323-2325, 1991.

[3] H. Tong, M. Li, H. Zhang, and C. Zhang, "Blur detection for digital images using wavelet transform", Proc. IEEE International Conference on Multimedia and Expo, vol. 1, pp. 17-20, 2004.

[4] R. Dash, P. K. Sa, and B. Majhi, "RBFN based motion blur parameter estimation", in Proc. IEEE International Conference on Advanced Computer Control, Singapore, vol. 1, pp. 327-331, Jan 2009.

[5] K. C. Yang, C. C. Guest, and P. Das, "Motion blur detecting by support vector machine," Proceedings SPIE, pp. 5916-59160R, 2005.

[6] M. J. Chen and A. C. Bovik, "No-reference blur assessment using multi-scale gradient," Proc. 1st International Workshop on Quality of Multimedia Experience, San Diego, California, 2009.

[7] F. Krahmer, Y. Lin, B. McAdoo, K. Ott, J. Wang, D. Widemann, and B. Wohlberg, "Blind image deconvolution: Motion blur estimation", Tech Rep., Univ. Minnesota, 2006.

[8] R. Lokhande, K. V. Arya, and P. Gupta, "Identification of blur parameters and restoration of motion blurred images", Proc. ACM Symposium on Applied Computing, pp. 301-305, 2006.

[9] X. Y. Fang, H. Wu, Z. B. Wu, and B. Luo,"An improved method for robust blur estimation", Information Technology Journal, vol. 10, pp. 1709-1716, 2011.

[10] M. Rekleities, "Steerable filters and cepstral analysis for optical flow calculation from a single blurred image", Proc. the Vision Interface Conference, oronto, Ontario, Canada, pp. 159–166, May 1996.

[11] Y. S. Yoshida, K. Horiike, and K. Fujita, "Parameter estimation of uniform image blur using dct", IEICE Trans. Fundamentals, vol. E76, no. 7, pp. 1154-1157, July 1993.

[12] S. Tiwari, A. K. Singh, and V. P. Shukla, "Certain investigations on motion blur detection and estimation", Proc. International Conference on Signal, Image and Video Processing, IIT Patna, pp. 108-114, Jan. 2012.

[13] R.C. Gonzalez, R.E. Woods, “Digital Image Processing”, 2nd ed., Addison Wesley,Upper Saddle River, New Jersey, 1992.

[14] R. Neelamani, H. Choi, R.G. Baraniuk, “ Forward: Fourier-wavelet regularized deconvolution for ill-conditioned systems”, IEEE Transaction on Signal Processing 52 (2) (2003) pp. 418–433.

[15] M. Figueiredo, R. Nowak, “An EM algorithm for wavelet-based image restoration”, IEEE Transaction on Image Processing 12 (8) pp 906–916, (2003).

[16] R. Lokhande, K.V. Arya, P. Gupta, “ Identification of parameters and restoration of motion blurred images”, Proceedings of the 2006 ACM Symposium on Applied Computing, of SAC 2006, Dijon, France, vol. 9, pp. 301–305, 2006.

[17] M.E. Moghaddam, M. Jamzad, “ Motion blur identification in noisy images using mathematical models and statistical measures”, Pattern Recognition 40, pp. 1946–1957, (2007).

[18] W.-G. He, S.-F. Li, G.-W. Hu, “Blur identification using adaptive adaline network”, in: IEEE International Conference on Machine Learning and Cybernetics, Guangzhou, China, , pp. 5314–5317, 2005.

[19] Aizenberg, D.V. Paliy, J.M. Zurada, J.T. Astola, “Blur identification by multilayer neural network based on multivalued neurons”, IEEE Transaction on Neural Networks 19 (5), pp.883–898, (2008).

[20] Ratnakar Dash, Banshidhar Majhi, “Motion blur parameters estimation for image restoration”, International Journal for Light and Electron Optics, vol. 125, Issue 5, pp 1634–1640, Elsevier-March 2014

[21] Zhao Peng etal, “Image restoration for interlaced scan CCD image with space-variant motion blurs”, transaction of optics and laser technology, vol. 42, Issue 6, pp 894–901, Elsevier- September 2010

[22] Deyi Ma etal, “fast render algorithm of virtual and real motion blur consistence in augmented reality”, transaction of Elsevier- September 2013.

[23] Glenn Shafer, “Perspectives on the theory and practice of belief functions,” International Journal of Approximate Reasoning vol. 4, Issues 5–6, , Pages 323–362, Elsevier- September–November 1990

[24] Annu Gupta”Image deblurring with filtering approach,” International Journal of Research in Advent Technology (IJRAT), ISSN: 2321-9637, vol. 1, No. 2, September -2013.