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IMAGE RESTORATION BASED ON UNSYMMETRIC FUZZY SWITCHED STEERING KERNEL

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ABSTRACT

The Digital image restoration is one of the image processing techniques that deals with the methods used to recover an original image from a degraded image. The proposed work is done for high density impulse noise which is affected by gaussian blur and is solved by using fuzzy filtering techniques for denoising and a Noise Suppressed Steering Kernel for deblurring which is a hybrid method. In the previous work the outputs suffering with spurious edges in the case of denoising. The above disadvantages of the steering kernel are overcome by using median filters. The presence of spurious edges on iterative process gets added up and becomes stronger if not removed. Hence it can be eliminated by using median filters at the end of the each iteration, since this method is an iterative process. A noise suppressed steering kernel NSSK is used in the proposed method.
Keywords: *Image restoration, Fuzzy filter, Steering kernel, Noise suppressed steering kernel.*

1. INTRODUCTION

In the field of image processing digital image restoration is one of the processes to recover an original image which is degraded. Blur and noise are the two common problems that exist in digital imaging. It happens during important camera setting that strongly affects these two issues. If the exposure time is fixed, a large aperture will increase the signal to noise ratio, mean while reducing the depth of field and thus increasing the out-of-focus blur, which eliminates high-frequency components of the image. On the other hand, a small aperture will alleviate the blur but increase the noise level. Noise can also be suppressed by using longer exposure time but of course, this may cause motion blur that is even more difficult to remove. At the same time, limited accuracy of auto-focus systems and low light condition may add extra blur and noise into the image. So in real applications, such as consumer digital imaging, it is very common to record weakly blurred and relatively noisy images.In digital image restoration regression is one of the process of recovering original image which is affected by noise or blur. The image can be recovered by using denoising and deblurring techniques. Basically regression has two techniques .The first one is parametric regression which is based on some specific model for the underlying original data and analyses and estimates based on those parameters. The second one is non-parametric regression which is based on data itself instead of assuming a specific model for the original data. There are lots and lots of methods are used for denoising and debluring.

In the previous method steering kernel is used for deblurring the image it gives better results when comparing other methods. So the disadvantages in the previous method are that the output of the image gets smoothening. In order to overcome this issue a Noise Suppressed Steering Kernel and median filter is used in the proposed work. The input image is taken and gaussian blur is added, then add impulse noise and use fuzzy rule for denoising.Then use steering kernel for deblurring the image, finally the output image is got with removal of noise and blur. This section gives an introduction of the existing work and proposed work. The

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second section illustrates on fuzzy techniques for denoising and the third section illustrates steering kernel for image deblurring. The fourth section illustrates the Noise Suppressed Steering Kernel and the last section gives the result and analysis.

2. LITERATURE REVIEW

The digital image restoration is challenging in the field of computer science and its application. The ultimate aim of image restoration is to bring a better result when an image is degraded. Image degradation is happened in so many reasons, it happens due to miss focus of camera, camera settings, environmental changes etc. In order to rectify this issue lots and lots of methods are proposed for bringing better results. AtoniBuades et al [1] proposed a measure called noise for evaluation and comparison of denoising methods. Initially the above said noise measure is computed and analyzed for local smoothing filters and then a new algorithm called "Non-Local means" is proposed as the result of non-local averaging of the pixels of an image. Bart Goossens et al [2] improved the NL means algorithm and extended to reduction of colored or correlated noise which resulted in better denoising compared with wavelet based techniques. Haichao Zhang et al [3] presented Non Local Kernel Regression model using structural and similarity properties in images. The properties are non-local self-similarity and local structural regularity. The model can be applied in denoising, deblurring and also reconstruction of both images and videos. [4]

The conjunctive deblurring algorithm (CODA) was able to handle large blur. In CODA the temporal kernel is computed by using the large steps restored by the deterministic filter. Therefore if the image structures are dominated by narrow edges, CODA cannot produce an accurate blur kernel and it can be applied to other Basyian Estimation based problems, such as image denoising, unsampling, matting and impainting. [5] Jian-FengCai states how to recover a motion blurred image due to camera shake by using a regularization-based approach to remove motion blurring form the image by regularizing the sparsity of both the original image and the motion blur kernel under tight wavelet frame system. This method was not able to deal with nonuniform motion blurring, including image blurring caused by camera rotation and partial image blurring caused by fast moving objects in the scene. [6] HuiJi and Kang Wang proposed a robust image deblurring with an inaccurate blur kernel method can either be used to deblur images when only the blur kernel of low quality is available or can be used to deblur images blurred by complex blurring processes such as spatially varying motion blurring.

3. IMAGE DENOISING USING FUZZY TECHNIQUE

This is one of the machine learning concepts. The machine learning concept is divided into two categories namely artificial neural network and fuzzy logic. In artificial neural network the input and output must be declared and trained based on the application. The fuzzy logic technique is used to certain application based on which the user fix some criteria. Fuzzy logic represents a powerful approach to decision making. Since the concept of fuzzy logic was formulated in 1965 by Zadeh, many researchers have been carried out on its application in the various areas of digital image processing such as image quality assessment, edge detection, image segmentation, etc.

In fuzzy technique there is a membership function which will decide the criteria. There are three types of membership function applied in the proposed work. The first function is named as small negative, second function is negative and third function is large negative. This is known as tramp type membership function. These function come under trapezoidal membership function .This is applied based on the rule which is created to the input image.

In the proposed work a high density impulse noise image is taken in order to denoise using fuzzy technique which has the noise level at high density. From the input image a 3 x 3 matrix is taken to compare the center pixels with the neighbor pixels where 0 as low frequency and 255 as high frequency. The noise level is high in the image and edges also shown as noise. Once the denoising is applied to the input image it removes the high density pixel values in which the edges are also removed. Next we generate fuzzy rules for the 3 x 3 matrix. The rule is generated for 0^{th} pixel to 9^{th} pixel. From 0 to 4 we assign the membership function as small negative in which when the noise fall between 0 to 4 it assign as small negative shown in the

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figure 1.0. The next membership function takes the pixel value from 4 to 6, when the noise fall in this pixel it will consider as negative shown in the figure 1.1. When the noise fall on the pixel value from 6 to 9 it is named as large negative shown in the figure 1.2.

3.1 Rule generation

In the proposed work we have generated four rules.

a. When f0 is small negative and f255 is negative the system generate mean for the corresponding pixel.
b. When f0 is large negative and f255 is small negative the system generate standard deviation.
c. When f0 is negative the system generates median operation.
d. When f255 is positive the system generates mean operation.

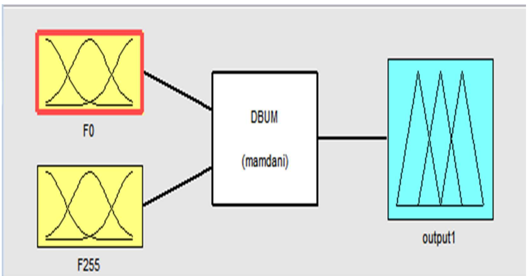

Figure 1.0 Fuzzy System

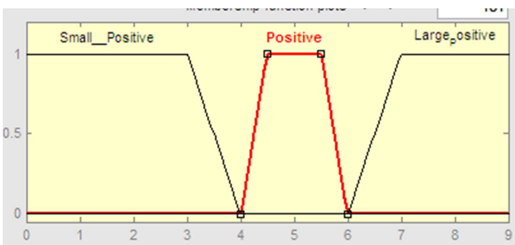

Figure 1.1 F0 membership function

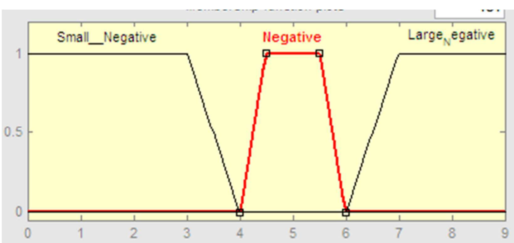

Figure 1.2 F255 membership function

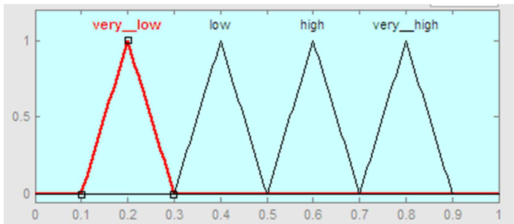

Figure 1.3 Fuzzy Outputs

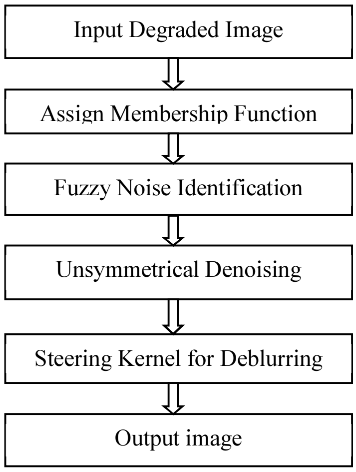

Figure1.4: Overview of the proposed method

In the figure 1.3 shows the overview of the proposed method.

Step 1: First get an input degraded image is taken for the process.
Step 2: Assigning fuzzy membership function for degraded image.
Step 3: Noise identification using fuzzy rules.
Step 4: Unsymmetrical denoising based on fuzzy output.
Step 5: Next use Steering kernel for Deblurring the image.
Step 6: Finally the original image is recovered by using a Noise Suppressed Steering kernel.

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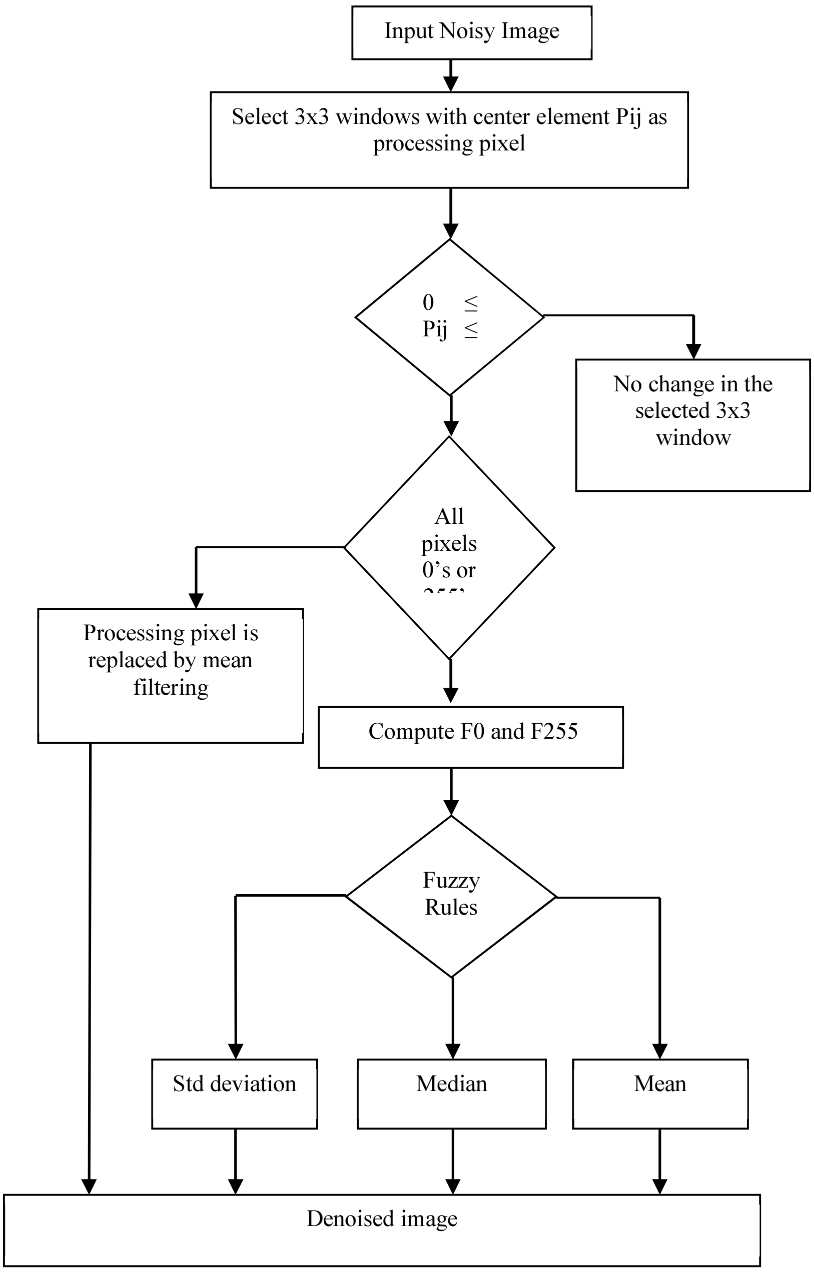

Figure 1.5: Flow chart of fuzzy denoising

The above flowchart describes the functionality of image denoising using fuzzy technique. First the input image of 3x3 windows is taken with the center element Pij as processing pixel. Then computes when the processing pixcel $0 \le Pij \le 255$, then there is no change in the selected 3x3 window. When all pixels are 0's or 255's then compute processing

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pixel is replaced by mean filtering. Now compute f0 and f255 by using fuzzy filtering. Now fuzzy rules are applied based on pixel values. Based on pixel value fuzzy will decide to calculate standard deviation, mean and median. Finally the image is denoised using fuzzy filtering technique.

4. NOISE SUPPRESSED STEERING KERNEL

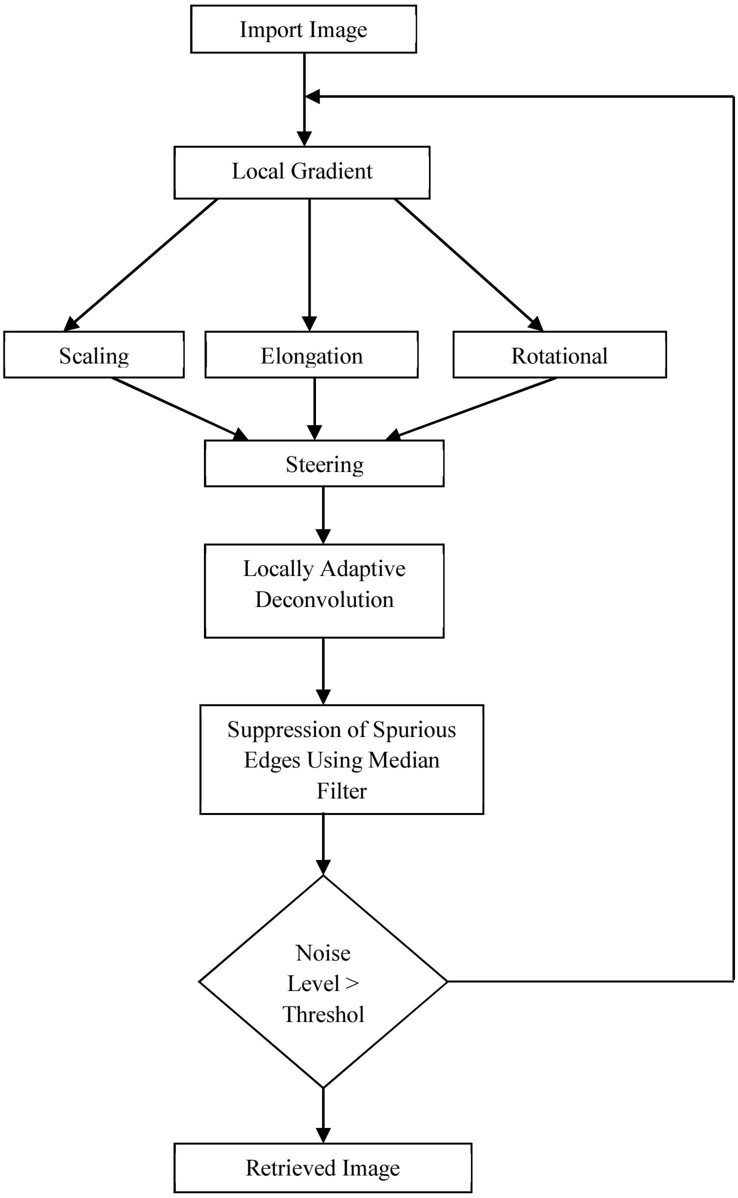

Figure 1.6: Flowchart of Noise Suppressed Steering Kernel

The traditional process of steering kernel regression technique is a non parametric approach of regression which involves directly on the data itself instead of depending on any specific model. The above method outputs spurious edges when noise is high. The presence of spurious edges on iterative process gets added up and becomes stronger if not removed. Hence it can be eliminated by using median filters at the

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end of all iteration. This method has the following steps.

1. Importing image
2. Formulating image and local gradient.
3. Parametric analysis
4. Steering matrix formation
5. Application of steering kernel
6. Suppression of spurious edges
7. Thersholding

4.1. Importing Image:

The image needed to be edge detected is chosen from the database of images. All the initial process of making the image ready for further processing is to be performed. The initial process includes enhancing quality, cropping the image, resizing the image, etc,

4.2. Formulating image and local Gradient:

An image gradient is a directional change in the intensity or color in an image. Image gradients may be used to extract information from images. Gradient is one of the important parameters used for image processing. The gradient of the image is given by using the formula

$$\nabla g = \frac{\partial g}{\partial x} * \bar{x} + \frac{\partial g}{\partial y} * \bar{y}$$

Where, $\frac{\partial g}{\partial x}$ is the gradient in x direction,

$\frac{\partial g}{\partial y}$is the gradient in y direction.

After calculating the image gradient, local gradients are to be found. Local gradient are used to formulate the various parameters of the image.

4.3. Parametric analysis:

Gradient of an image can be used to analyze various parameters such as scaling parameters, Rotational parameter and elongation parameter. Scaling parameters provide information on sizes of the image. Rotational parameters are one associated with defining on what angle the image is been located or rotated. Elongation parameter is those which imply how the image has been elongated.

4.4 .Steering matrix formation:

A new approach of de-blurring is carried out using steering kernels regression technique. Steering kernels regression is carried out using steering matrix. Steering kernel regression is a non parametric regression technique. It involves non linear combination of data i.e. the data not only depends on sample location and density but also on the radiometric properties. This method adapts the regression kernel locally so that the kernels arrange themselves along the features instead of arranging across them. Features include edges. The processes behind steering kernel regression are given below. The measured data of steering kernel is represented as,$m_i = r(d_i) + \alpha_i$where$i = 1 \dots p$

Where

r (d_i)= regression function acting on pixel coordinates,

α_i = zero mean noise values distributed identically and

p= total number of pixels.

The steering kernel is mathematically represented as

$$SK(y_l - y_i) = \sqrt{\det(CV_l)}\exp\{-(y_l - y_i)^T CV_l (y_l - y_i)\}$$

Where,

y_i = center pixel where steering kernel (SK) window is located,

y_l= locally selected pixel within SK window,

CV_l=Covariance matrix with window around y_l.

4.5. Noise suppresses multi computing steering kernel

The final noise suppresses multi computing kernel is obtained from the steering kernel using the formula,

$$k = SK + sF \otimes SK$$

Where,

k= noise suppresses multi computing kernel,

SK = Steering kernel,

s = degree of sharpening,

F = Laplacian filtering

$\otimes$ = convolution operator.

4.6. Suppression of spurious edges:

The image after performing all the above steps contains some noise in it. When this output image is subjected to iterations it will keep on increase the noise content. So in this proposed method the noise content is removed before letting the image into next iterations so that the noise won't get added up. The noise i.e. the spurious edges is removed by passing the image into a median filter and then allowed for iterations.

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4.7. Thresholding:

After the spurious edges are being removed the output image is subjected to a process of thresholding. The output values are being compared with one defined value which is the threshold value such that the output image values are compared with this defined value. If the appropriate threshold condition is not met the whole process will repeat from the initial stage of taking gradient. If it is met the obtained output is the final de-blurred output.

5. RESULT AND ANALYSIS

The proposed fuzzy denoising with noise suppressed steering kernel deblurring and other existing algorithms in the literature are implemented and the results are shown in figure 1.7 anf 1.8. It has been explicitly proven that the image applied with proposed algorithm is denoised and deblurred with better clarity. The comparative analysis is done based on Gaussian blur level as shown in the Table-1. Statistically the improvement of the proposed method is proved with the help of graph plotted with PSNR against the noise level as shown in the figure 1,7.

In the figure 1.7 a standard Lena image is taken as an input image and in the first step a blur is applied in the figure 1.7. (b) Then addition of noise is added. In the next step a blind deconvolution is applied shown in the figure 1.7. (d) It shows better result from blind deconvolution. Next an inverse filtering is applied shown in the figure 1.7. (e), it shows better result when comparing previous methods.

For implementation latest version of MAT LAB is used. For the purpose of analyzing the proposed method, the latest version of MATLAB called MATLAB 2013 is used, and its performance can be measured in terms of CPU time by means of virtual cores. The CPU uses multi threading to perform multiple operations. However, Intel CPU with hyper threading contributes the appearance of a computer with multi cores. It uses 2 GB RAM memories and a half of the core is being utilized for using tools such as the Windows Task Manager. Data are computed with the help of the Pentium processor, thus increasing the performance without any congestion in the data bus.

Figure 1.7 Results for noise corrupted lena image (a) Original image (b) Blurred image (c) Blurred with noise image (d) Blind Deconvolution (e) Inverse Filter (f) Lucy-Richardson Filter (g) NLKR Deblurring (h) Proposed method

(a). Original image

(b). Blurred image

(c). Blurred with noise image

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(d). Blind Deconvolution

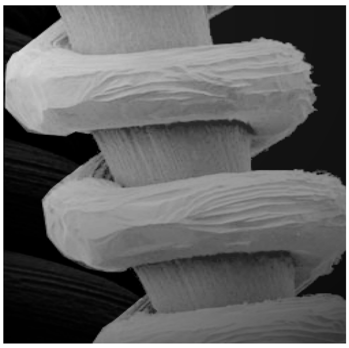
(e). Inverse Filter

(f).Lucy-Richardson Filter

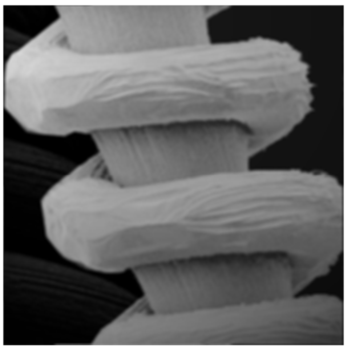
(g). NLKR Deblurring

(h). Proposed method

Figure 1.8 Results for noise corrupted rope image (a) Original image (b) Blurred image *(c)* Blurred with noise image *(d)* Blind Deconvolution *(e)* Inverse Filter *(f)* Lucy-Richardson Filter *(g)* NLKR Deblurring *(h)* Proposed method



(a). Original image



(b). Blurred image

(c). Blurred with noise image

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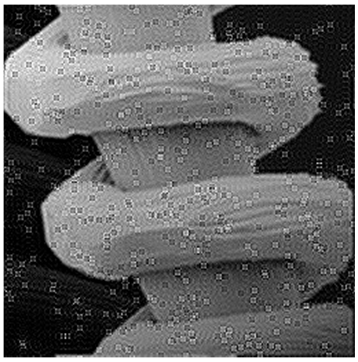
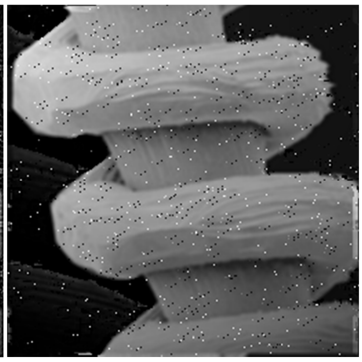
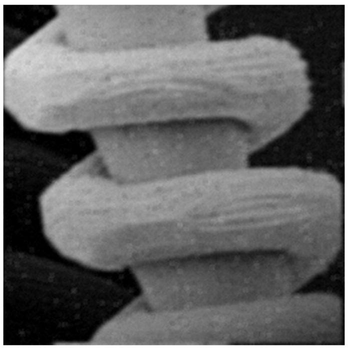
(d). Blind Deconvolution



(e). Inverse Filter



(f). Lucy-Richardson Filter



(g). NLKR Deblurring

(h). Proposed method

COMPARISON, Gaussian blur level (lambda=3,sigma=8)						
IMAGE NAME	**NOISE RANGE**	**BLIND DECONVOLUTION**	**INVERSE**	**LUCY RICHARDRSON**	**NLKR**	**PROPOSED METHOD**
Lena	0.01	17.27	17.92	16.15	24.24	28.39
	0.05	14.63	13.59	11.47	18.66	21.26
	0.1	12.82	11.16	9.66	16.08	17.78
Einstein	0.01	17.21	16.96	18.17	21.99	24.3
	0.05	15.31	13.5	12.71	18.37	19.49
	0.1	14.52	11.09	10.88	15.88	17.2
Rope	0.01	17.07	17.82	16.05	24.27	26.83
	0.05	14.37	13.42	11.28	18.48	23.33
	0.1	12.53	11.11	9.59	16.01	19.08

Table I: Comparison of PSNR Values Of Different Algorithms for Image at Different Noise Densities

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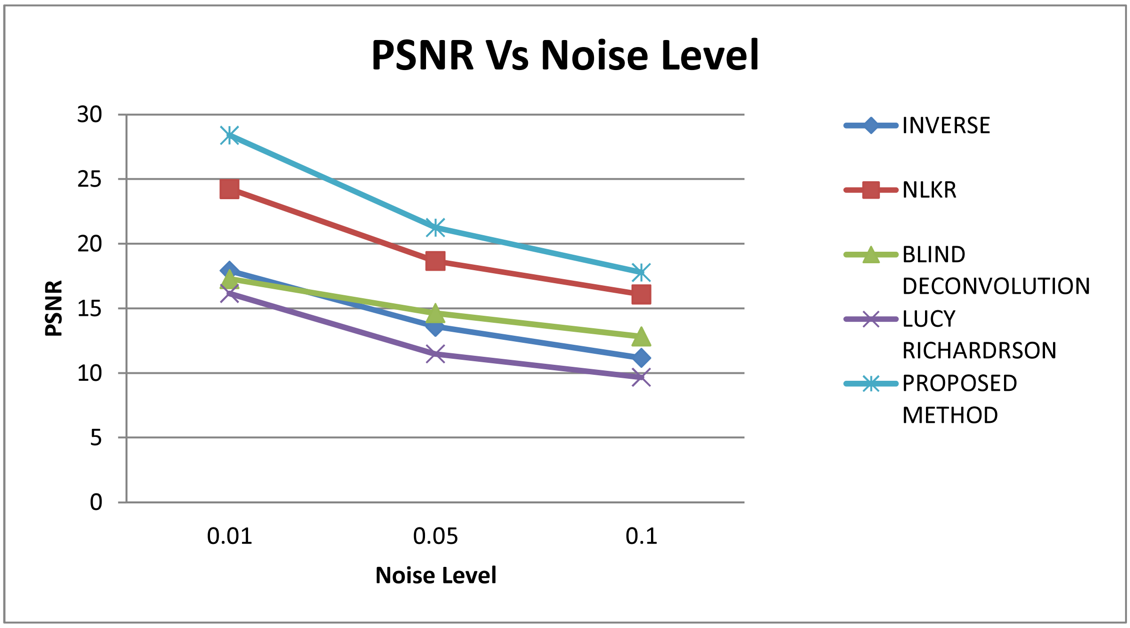

Fig 1.9 PSNR DB Vs Noise Density %

CONCLUSION

In this paper, A Noise Suppressed Steering kernel is used for deblurring and fuzzy filtering is used for denoising. This method is used in applications when the image is affected by combination of impulse noise and gaussian blur .The Experiments show that the proposed approach can efficiently restore images distorted by impulse noise and Gaussian blur .The proposed method is compared with other algorithms and able to produce better results. Compared with other state of the art adaptive sharpening methods, it handles both Denoising and sharpening tasks simultaneously very well. Since it is an iterative process the only issue is time complexity, because fuzzy filtering takes some time for decision making of noise detection. Even it takes time and produce better results than other methods and the system is able to produce good results is minimum configuration. The proposed method is demonstrated by experimental results which exhibit significant improvement over several other methods.

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