Performance Analysis and Optimization of Nonlinear Image Restoration Techniques in Spatial Domain

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Abstract

This paper is concerned with critical performance analysis of spatial nonlinear restoration techniques for continuous tone images from various fields (Medical images, Natural images, and others images).The performance of the nonlinear restoration methods is provided with possible combination of various additive noises and images from diversified fields. Efficiency of nonlinear restoration techniques according to difference distortion and correlation distortion metrics is computed. Tests performed on monochrome images, with various synthetic and real-life degradations, without and with noise, in single frame scenarios, showed good results, both in subjective terms and in terms of the increase of signal to noise ratio (ISNR) measure. The comparison of the present approach with previous individual methods in terms of mean square error, peak signal-to-noise ratio, and normalized absolute error is also provided. In comparisons with other state of art methods, our approach yields better to optimization, and shows to be applicable to a much wider range of noises. We discuss how experimental results are useful to guide to select the effective combination. Promising performance analyzed through computer simulation and compared to give critical analysis.

Keywords: Nonlinear Image Restoration, Correlation Distortion Metrics, Median With Weight in Spatial Domain, Additive Noise

1. INTRODUCTION

The need for efficient image restoration techniques has grown with the massive production of digital images from various fields often taken in noisy conditions. No matter how good image sensors are, an image restoration is always desirable to extend their various types of transmission media. So it is still exigent problem for researchers. Digital image is generally encoded as a matrix of gray level in continuous range called continuous tone image (CTI). The two main limitation in image accuracy are categorized as blur and noise, blur is intrinsic to image acquisition system [1] and second main image perturbation is the different type of noises. Nonlinear restoration techniques deal with those images that have been recorded in the presence of one or more sources of degradation. Spatial domain is based conditionally on the values of the picture element in neighborhood under consideration and employ a low pass filtering on groups of picture elements the higher region of frequency spectrum [2]. Variety of nonlinear relaxed median and considering weight rank selection have been implemented in MATLAB 7.2.0 to see the suitable combination according to the noise and nonlinear restoration technique, as well as to find efficiency of nonlinear filtering by using various quality metrics. The performance of an image nonlinear restoration method depends on its ability to detect the presence of noisy picture element in the digital image. An interesting method for restoring of single type of image was proposed in[2] [3]. This method appears not to pose any strong restrictions on the degradation. In the cited paper, several experimental results on synthetic noises are shown, but little information is provided about them. From the information that is given, it appears that the degradation techniques that were used in the experiments either circularly symmetric or corresponded to straight line motion blurs. There seems to be no reason for the method not to be able to successfully deal with other kinds of noises, however the PSF, Gaussian, Speckle, Salt & pepper, and Poission noises are shown in this paper appear to have different density. The improvements in increase signal to noise ratio (ISNR) seem to be between particular ranges in dB for

specific standard deviation. The experimental result presented in section V show that, with much at particular density, our scheme at normally yielded to optimum selection according to larger improvement in nonlinear restoration methods.

In all cases, one has access to more than one degraded image from the same noise a fact which can be used to the ill-posedness of the problem. The scheme also assumed that the quality of the original image, before the degraded, as happens in most images from various fields.To the author's acknowledge, this is first scheme to be proposed, which is able to yield result of optimum selection in such a wide range of situations. The performance and robustness of the nonlinear restoration techniques were tested in various experiments, with synthetic and real life degradation without and with density of noises on the restoring filters, using monochrome images, and under the single frame. The quality of the results was evaluated both visually and in terms of ISNR, normalised mean square error (NMSE), Structural content (SC), absolute difference (AD),maximum difference (MD), normalised cross correlation i.e. correlation quality metric. Detailed comparisons of median, weighted median filtering methods (nonlinear restoration) with MSE, NAE, NMSE, PSNR, AD, MD, difference distortion metrics were evaluated, and show that the proposed scheme yields significantly better for optimum selection of restoration technique.

The remainder of the paper is organised as follows: Section II provides a background review on the concepts involved in nonlinear restoration and continuous tone image (CTI), discrete tone image (DTI), modelling different types of noise in brief. The median filter and weighted median filter implementation in section III. In section IV, results obtain from the nonlinear restoration techniques (distortion metrics, correlation metrics and histograms according to density of noise). In section V; we show comparative results according to combination of CTI, bad CTI and noise to non linear restoration technique. State of art and concluding remarks and future research directions are made in section VI.

2. BACKGRONUD REVIEW

In this section, we briefly review previous work on image restoration, continuous tone image model and noise modeling. Image restoration techniques differ in the choice of image prior model, and many noise estimation techniques assume synthetic degradations.

2.1 Continuous Tone Image and Noise Models

Image sequence $I(r,c,t)$, where t denotes time and (r,c) denotes a spatial location in image domain D. Let (r, c) denote displacement vector of point $(r,c) \in D$ from time t to $(t+1)$, that is $I(r,c,t) = I(r+p, c+q, t+1)$, where image intensity at an object point is assumed to be constant along its motion trajectory over time. For notational simplicity, it is noted that in above equation, the motion components p and q are simplicity function of both (r,c) and 't' [4].Contaminated continuous tone image model considered for analysis as equation, $g(r,c) = \sum_{j=0}^{n-1}\sum_{i=0}^{n-1} f(i,j)\, h(r-i, c-j) + n(r,c)$, for $r = 0,1,2,\ldots.M-1$ and $c = 0,1,2,\ldots.N-1$. In matrix vector notation representation is $g = hf + n. g, f \text{ and } n \text{ are } MN$ dimensional vectors and h is $(MNXMN)$ block circulant matrix represents degradation process embedded in continuous tone image formation process, g vector from the given matrix $\{g(r,c)\}$ is $g(r,c) \in \{0,1,2,\ldots.L-1\}$. Many two tone image processing algorithms are considering, only entire rectangular domain of the continuous tone image [5].

We have considered spatial degradation models for analysis are commonly i) Atmospheric turbulence ii) Motion blur iii) Defocused system. Space-invariant point spread function for mentioned types are described in detail [6][11]. All noises occur in spatial domain modeled as Gaussian, Speckle, Poission and Salt & Pepper. According to application Gaussian noise is distributed over signal while transmission by $f(g_t) = 1/\sqrt{2\pi\sigma^2}\, e^{-(g-m)^2/2\sigma^2}$, which has bell shaped PDF [8]. Salt & Pepper is an impulse noise, it is generally caused by malfunctioning in picture element in common sensors, faulty memory location or timing problem in quantization process, transmission line is not installed properly [8][9]. Speckle noise occurs in almost all coherent imaging system such as laser acoustic and synthetic aperture radar imagery. Distribution of speckle noise $f(g_s) = \frac{g^{\propto-1}}{(\propto-1)!a^{\propto}} e^{\frac{g}{a}}, a^2$ is density of speckle noise and $\propto, g$ are the picture elements. The Poisson distribution is a one parameter of discrete distribution that takes non-negative integer values. The parameters, both the mean and the variance of the distribution. Thus, as the PDF of Poisson noise is $f\left(\frac{x}{\gamma}\right) = \frac{\gamma^x}{x!} e^{-\gamma} I_{(0,1,2,\ldots\ldots)}(x)$ [10]. CTI an image, Such as a photograph, where gray levels in the image are continuous not discrete and it contains gradient tone, it allows 256 density levels per color [12].

3 SPATIAL NONLINEAR RESTORATION TECHNIQUES

Median filter is nonlinear filter which preserves edges while effectively removing the noise. Median operations are performed by row sorting, Colum sorting and diagonal sorting in matrix [8] [10] [18]. General median filter often exhibit blurring for large window sizes, or insufficient noise suppression for small window sizes.

3.1 Median and With Weights Filter

In previous work, a variety of restoration techniques have been developed in the image processing and computer vision communities. Although seemingly very different, they all share same synthetic noises but only on single type of image. We categorize existing image restoration work in spatial domain by heir single type of image prior and the corresponding representation of type of image statistics.

Objective of the nonlinear restoration technique [9] [10] is to improve the initial continuous tone image means reduce the noise, to increase the contrast, to highlight boundaries and mentioned parameters estimated. Nonlinear filter is robust whose output is not linear to function of input. One of the most commonly used nonlinear filters is the median in spatial domain and major advantage to eliminate the effect of input noise values with extremely large magnitude [15].Median (m) value of a set of numbers is the midpoint value in that set, ‘m’ is highest likelihood leads to a loss of details; however it is quite distinct from that of ‘m’. We are applying 3x3 median filter to all considered noises, which requires an extended length L=15. Spatial median filter (SMF) and vector median filter (VMF) are similar although SMF unbiased [16] so it called smoothing algorithm.

Median with weights which contain positive integer weight expressed for discrete time continuous valued input vector $x = [x_1, x_2, x_3, \ldots x_N]$, and output Y of SMF of width N with corresponding integer weights are $w = [w_1, w_2, w_3, \ldots\ldots w_N]$, actual response $Y = med[x_1 * w_1, x_2 * w_2, x_3 * w_3 \ldots\ldots\ldots x_N * w_N]$. The ‘$m$’ is chosen from the sequence of the products of the sample and their corresponding weights. Positive non-integer weights expressed as weighted median of ‘x’ is the value of β minimizing the expression $L(\beta) = \sum_{i=1}^{N} w_i |x_i - \beta|$. The picture element in particular window size of an image are assigned weights according to weight matrix, sorting image vector and center value can be considered as the median [16].

4. NOISE ESTIMATION BY QUALITY MEASURES

Image dependent noise can be estimated from multiple frames or single image. Estimation from multiple images is an overconstrained problems and mentioned [17]. Estimation from single frame, however is an underconstrained problem and further assumption have to be made for degradation. In the image restoration literature degradation often assumed to be an white Gaussian noise. A widely used estimation techniques are based on the mean absolute deviation [18].In [19] the quantitative measures are estimated for each intensity in spatial domain. A.stefano and P. whites system was based on training samples in other domain only for natural images [20]. Generalization expectation maximization restoration techniques in any domain developed and estimate the spectral features.

The scheme for restoration followed by synthetic degradation to give the optimum solution for restoration of degraded images from diversified field. Signal-dependent degradations is calculated from the smooth region of the image by segmenting the image gradient with an adaptive threshold in different domain for specific type of image [21]. By comparing our system provide optimization up to some extend for synthetic and real life degradations in branded camera used. And scheme provides a principled way for selecting nonlinear restoration techniques for estimating the quality of degraded images under various density of noise from diversified field.

4.1 Difference Distortion Metrics

The subjective measures that we used for evaluating the quality of result of restoration tests are mean square error and normalized mean square error, assume that x_0 is an original image, y degraded (with noise) version of that image and x is a restored image, obtain from y .It can be computed by equations (1) .

$$NMSE = \frac{1}{MN}\sum_{MN}(x_0 - x)^2 / \sum_{MN} x_0^2 \quad \text{.......... (1)}$$

Maximum Difference, Absolute Difference, Structural Content, difference distortion metrics can be calculated twice one, between original and noisy second between original and restored image as following equations (2) respectively as.

$$AD_{1,2=} \sum_{i=0}^{N-1}\sum_{j=0}^{M-1}(x_0 - y)/MN \quad \text{............... (2)}$$

The performance evaluation of the restored image quality is measured objectively using maximum difference (MD), normalized absolute error (NAE), and normalized mean square error (NMSE). Moreover, observers do the subjective performance assessment. From this experimental evaluation, it can be concluded that objective assessment alone is not suitable objective scale to evaluate the quality of the restored image. Therefore, subjective assessment is very important to take into account visual quality. Normalized cross correlation has been computed in the spatial domain for feature matching of restored image.

4.2 Correlation Distortion Metrics

There are two measures used for evaluating the correlation quality of the result of restoration are Normalized Cross Correlation (ncc) and Normalized Absolute Error (nae). we start by defining the “signal” as image 'x'_0" , y degraded (with noise) version of that image and 'x' is a restored image, obtain from 'y' . It can be computed by equations (3) as

$$ncc = \sum_{MN} (x_0 - y) / \sum_{MN} x_0^2 \dots\dots\dots \quad (3)$$

However, the computation of meaningful increase in signal to noise ratio ($iSNR$) in restoring situation raises some special issues that we now address. We start by recalling basic concept of $iSNR$, the noise of 'y' as $(y - x_0)$, and the noise of 'x' as $(x - x_0)$. $iSNR$ of the restored image 'x' relative to the degraded image y is, then, the difference between the SNR of 'x' and SNR of 'y'. It can be computed, in decibels, as

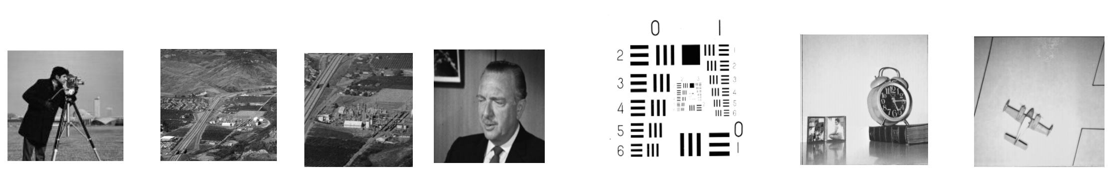
$$iSNR = 10 \log_{10} \frac{\sum_i (y^i - x_0^i)^2}{\sum_i (x^i - x_0^i)^2} \dots\dots\dots \quad (4)$$

Where the superscript $'i$ indexes the images' pixels, and the sums run through all pixels. The special issues arises in the computation of this measure in restoration situation, are due to the following. The restoration problem is strongly ill-posed. This means that non-regularized solution have a large degradability. There are four kinds of degradation that occurs are mentioned in 2.1. This degradation should be taken into account by the quality measure.

Analysis of restoration techniques based on gray level histogram contains two regions of interest: object and background [12]. As a result of these restoration techniques, the gray level histogram may change according to noise added in the continuous tone image.Most importantly we have learnt about histograms. Histograms tell us how the values of individual pixels in an image are "distributed". An image may have the same histogram as another image. Histogram similarity can be computed as $hc = \sum_{c=0}^{255} \left| f_1(c) - f_1{}' \right|$, where,f_1(c) is the relative frequency of level c in 256 levels continuous tone image [13]. Contrast enhancement plays a crucial role in image restoration application, such as digital photography, medical image analysis, remote sensing, and scientific visualization. There are several reasons for an image to have poor contrast, addition of synthetic noises, the poor quality of the used imaging device, faulty communication system, lack of expertise of the operator, and the adverse external condition at the time of acquisition. Several contrast analysis (Histogram) technique also have been adapted to restored, degraded, and original image. Other metric is called structural content ($SC_{1,2}$), it can also be computed by standard equation [10]. We have expressed that Autocorrelation of original image, and cross correlation of original x_0 and noisy y image and performing corresponding integration to find out single quantitative measure. It is shown in the next section of the paper.

5. EXPERIMENTAL RESULTS

The main experiment has been performed with on both synthetic and real life degraded gray scale images to test the nonlinear restoration techniques. Each image was degraded with Gaussian, Salt & Pepper, Speckle, Poission noises and PSF. The PSF is nonuniform-intensity circle, and simulates an out-of-focus degradation.



(a) **(b)** **(c)** **(d)** **(e)** **(f)** *(g)*

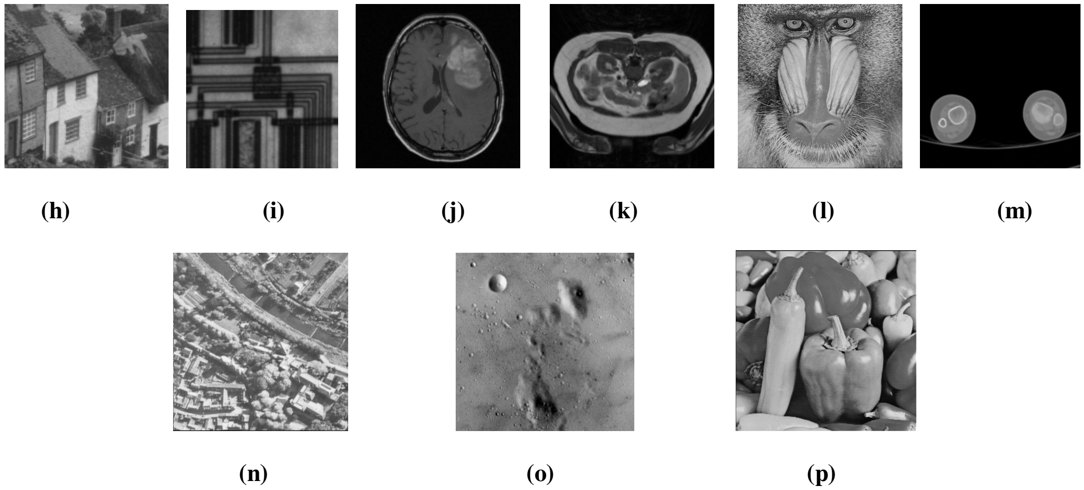


FIGURE 1: Set of typical gray scale images used in experiment (a) “cameraman” (b) “water” (c) “chemical plant” (d) “man” (e) “ resolution chart” (f) “clock” (g) “plane”. (h) “pic house” (i) “circuit” (j) “brain” (k) “liver” (l) “baboon” (m) “apperts” (n) “arial” (o) “planet” (p) “pepper” etc.

All images from various fields as Calgary corpus and some natural images from the Berkeley image segmentation database [19] are applied for experimentation. We tested the nonlinear restoration methods on different types of continuous tone images. We also performed comparisons with to each other on same data. Median and weighted median filters implementing in Matlab7.2.0. In the spatial domain, the PSF describes the degree to which an optical system blurs (spreads) a point of light [20] in weighted median filter. In this section, we first describe the experiment, which was intended at showing that effectively deals with a large variety of images and of noises.

Specially goals are: i) to examine the correlation quality between numerical results with ground truth data image (corrupted by additive noise) and results from experiments with original image ii) to quantify the performance in percentage (%) according to level of noise. And sequence of wide variety of noise density 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, and 0.10. Details parameters were computed on Intel core 2 duo system at 2.8GHz, programmed in Matlab for monochrome continuous tone 33 images of size 256x256 as shown in fig.1., about average time 30 seconds after adding degradation. Experiments are performed to observe the effectiveness of the nonlinear restoration techniques. The qualities of the various field images are compared in terms of visual quality and quality correlation parameters.

Table1 and table 2 gives a summary of the result, in terms of improvement in percentage according to MSE and NAE to different four types of synthetic degradation. Improvement is computed by, $|(MSEI - MSEII)/MSEI| X100$, where MSE-I is error after adding noise to original image and MSE-II is error calculated after restored an image in spatial domain.

For the comparison, we used four types of synthetic degradations. The synthetic degraded images were obtained from the gray scale images with noise which are mentioned in section 2 of this paper. Noises #1, #2, #3, #4 are Gaussian, salt & pepper, speckle, poission respectively and, therefore, is within the family of images for which the median filtering (nonlinear restoration) method is appropriate.

Types of images from various fields	Noises #1,#2, #3, #4 are Gaussian, salt & pepper, speckle, Poission respectively				Types of images from various fields	Noises #1,#2, #3, #4 are Gaussian, salt & pepper, speckle, Poission respectively			
	#1	#2	#3	#4		#1	#2	#3	#4
Camerama	58.17	85.80	52.53	19.46	Planet	74.41	**93.69**	65.51	41.40
Water	59.73	**92.94**	53.60	02.35	house	68.70	**91.20**	57.11	6.96
Chem.Plant	61.13	86.44	44.89	29.28	Pepper	76.77	**97.32**	**67.86**	61.34
Man	**79.78**	**98.23**	**70.22**	**74.71**	Liver	**77.88**	**98.88**	67.63	59.64
Reso. chart	25.94	73.96	36.66	69.47	Circuit	**77.47**	**98.64**	68.26	62.66
Clock	66.05	**92.00**	59.63	42.47	Brain	68.81	**95.35**	28.34	36.66
Plane	77.20	**97.42**	66.67	71.05	Baboon	05.59	36.41	01.20	**77.96**
Arial	59.5	86.29	54.73	6.75	Apperts	81.48	**98.70**	67.77	38.64

TABLE 1: Comparison of the result obtained after restored image on median filter. Each entry gives the improvement in % to four types of noise according to MSE for sixteen images, under the indicated conditions. The best performance for each case is shown in bold**,** Improvement in percentage according to mean square error of median filtering to different four types of synthetic degradation

Types of images from various fields	Noises #1,#2, #3, #4 are Gaussian, salt & pepper, speckle, Poission respectively				Types of images from various fields	Noises #1,#2, #3, #4 are Gaussian, salt & pepper, speckle, Poission respectively			
	#1	#2	#3	#4		#1	#2	#3	#4
Camerama	**43.82**	40.00	41.17	20.28	Planet	**53.33**	16.66	47.05	25.71
Water	47.82	28.57	**86.99**	11.90	house	47.36	**66.67**	41.17	11.84
Chem.Plant	**40.00**	11.11	35.29	11.76	Pepper	56.25	**70.00**	47.05	42.85
Man	59.09	**84.93**	52.94	62.50	Liver	53.33	**75.00**	47.05	44.42
Reso. chart	20.83	**50.00**	25.00	03.70	Circuit	53.84	5.00	47.52	39.08
Clock	47.57	**57.14**	35.71	40.00	Brain	45.00	**46.66**	23.52	02.77
Plane	53.92	**75.71**	50.00	53.57	Baboon	08.48	**55.58**	11.76	43.90
Arial	**39.16**	20.40	37.50	06.06	Apperts	**57.81**	**93.90**	47.05	38.96

TABLE 2: Comparison of the result obtained after restored image on median filter. Each entry gives the improvement in % to four types of noise according to NAE for sixteen images, under the indicated conditions. The best performance for each case is shown in bold, Improvement in percentage according to normalized absolute error (NAE) of median filtering to different four types of synthetic degradation

The result of the same experiment with Gaussian noise (zero mean with standard deviation varies from (0.01- to 0.10) are shown in fig.3. Similar performance increases by using nonzero values of mean can be observed, with again estimating

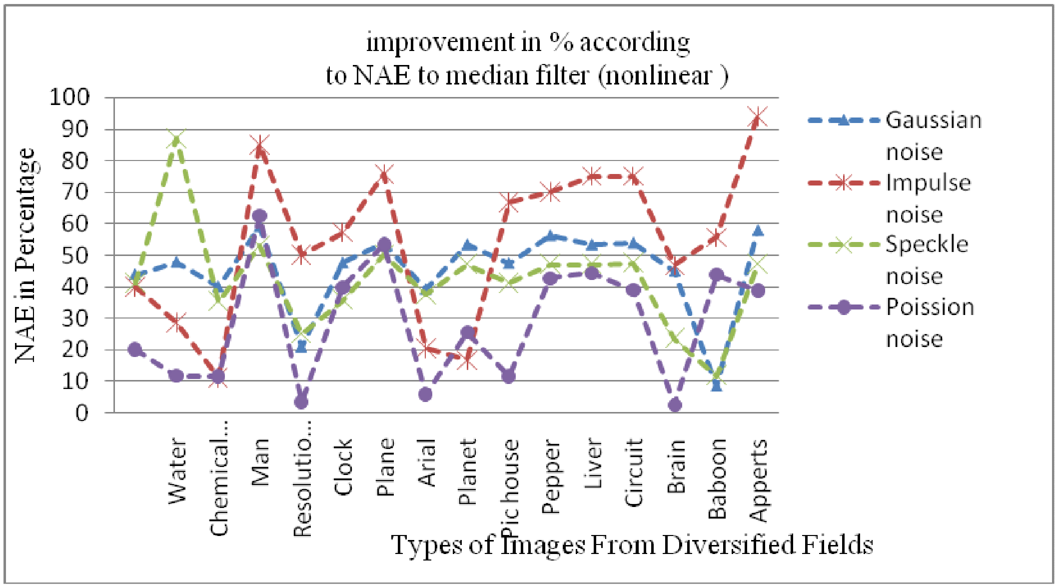


FIGURE 2: Number of images from diversified fields versus improvement in percentage according to normalized absolute error for the different four degradations; Gaussian, salt & pepper, speckle, poission noise

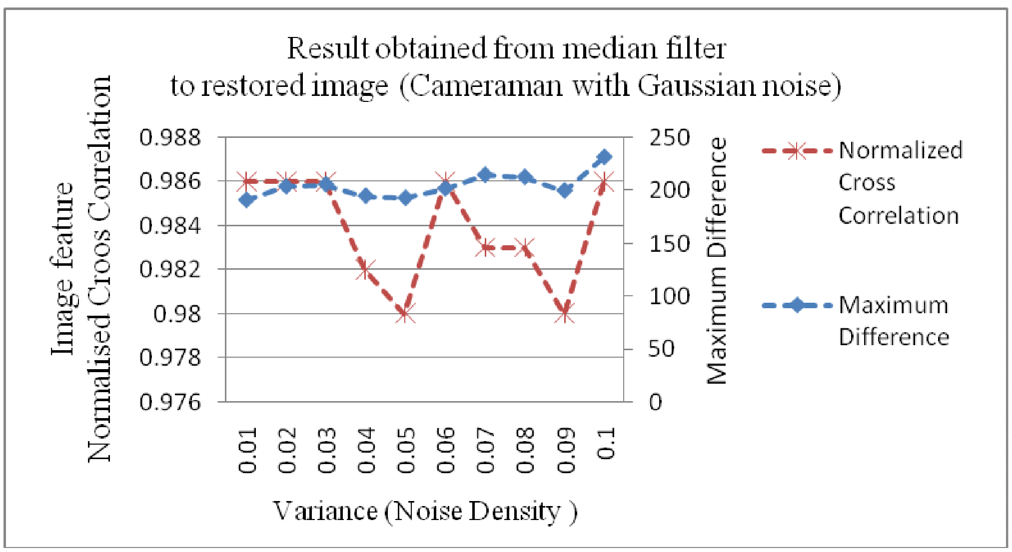


FIGURE 3: Noise density (standard deviation) versus normalized cross correlation and maximum difference of restored cameraman image with Gaussian noise

Weighted Median filter provides the consistence performance to all continuous tone images with Gaussian noise except for medical images which are having more Black back ground like brain and liver. Resolution chart and plane having remarkable result as shown in Table 3. Image of Chemical plant contains same things although this is from natural and Brain from medical field (x-ray), so visually performance of median filter is not up to the mark according, to obtained numerical results to Gaussian noise. It is effective for these four images from object oriented and some natural fields; otherwise we can apply to remaining images, if Gaussian noise is there, or else, we can't apply said restoration technique.

Images from diversified fields	MSEI noisy image /MSEII Restored image	Improvement according to MSE in %	Images from diversified fields	MSEI noisy image /MSEII Restored image	Improvement according to MSE in %
Cameraman	34/22	35.29	Water	30/20	33.36
Chem. Plant	34/24	29.41	Man	34/13	45.83
Resol. Chart	85/55	54.55	Clock	35/17	51.42
Plannet	29/12	58.62	Arial	41/28	31.70
Plane	28/16	42.85	Pic house	31/21	32.25
Pepper	30/23	23.34	Liver	20/11	45.00
Circiut	27/17	37.03	Brain	18/11	38.88
Baboon	43/36	16.27	Apperts	05/03	40.00

TABLE 3: Comparison of Improvement in parentage of diversified field images with MSE I (Degraded by Gaussian noise at noise density = 0.01) and MSEII (Restored images denoised by weighted median filter

Table 4 shows the ISNR values obtained with the synthetic degradation. We can see that, with nonlinear restoration method is clearly providing significant improvement in quality result. Nonlinear restoration method only yielded a significant improvement in image quality for the Gaussian noise with zero mean and standard deviation 0.01, as expected to natural images. When we used mentioned images with salt & pepper noise, which are most appropriate for aerial images. Nonlinear restoration method only surpassed in case of speckle noise to only planet and X-ray medical images. ISNR values attained in the tests described so far in some cases can be considered rather good, taking into account that the restoration methods under nonlinear techniques. In fact, these ISNR values are relatively close to the values attained by state of art restoration methods.

Various Types of images from diversified fields	ISNR values in dB with PSF#5, salt & pepper #6, Gaussian #7, speckle #8, respectively				Various Types of images from diversified fields	ISNR values in dB with PSF#5, salt & pepper #6, Gaussian #7, speckle #8, respectively			
	#5	#6	#7	#8		#5	#6	#7	#8
Cameraman	**16.30**	15.13	15.32	13.73	Planet	9.65	9.96	9.55	**10.08**
Water	**16.74**	16.57	16.60	16.67	house	9.62	12.60	9.72	**12.78**
Chem.Plant	14.86	12.55	12.83	**14.11**	Pepper	**13.08**	11.63	12.85	11.73
Man	32.25	**111.1**	34.44	43.13	Liver	4.99	6.13	**10.93**	5.80
Reso. chart	**8.44**	8.31	4.67	8.34	Circuit	23.7	21.12	5.71	**24.49**
Clock	5.79	**5.84**	5.67	5.52	Brain	1.14	0.93	**25.53**	1.83
Plane	5.47	5.61	**5.79**	5.64	Baboon	**9.80**	9.66	1.33	9.64
Arial	8.65	9.50	**9.55**	9.20	Apperts	36.08	**42.33**	8.89	32.88

TABLE 4 : ISNR values (in dB) obtained for nonlinear restoration method with PSF, Gaussian, Salt & Pepper, and Speckle noises to given sequence of images from diversified fields, the best result are shown in bold

Comparison of result obtained with and without Gaussian noise on the median filter. Each entry gives summation of Autocorrelation and cross correlation of original image with and restored image version of tested images. The correlation between two images is a standard approach to feature detection as well as a component of more sophisticated techniques of original, with degraded image and restored image. Required steps are shown in fig.5.

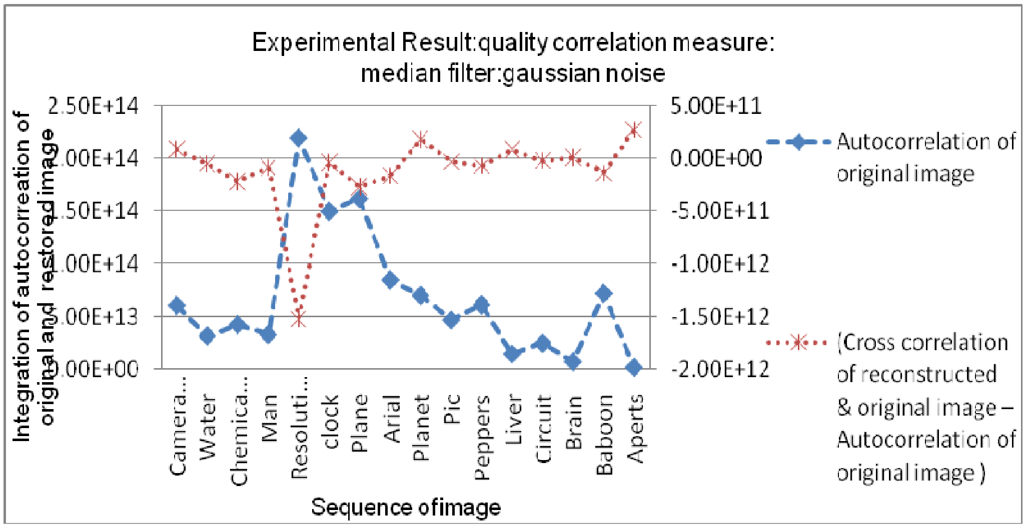
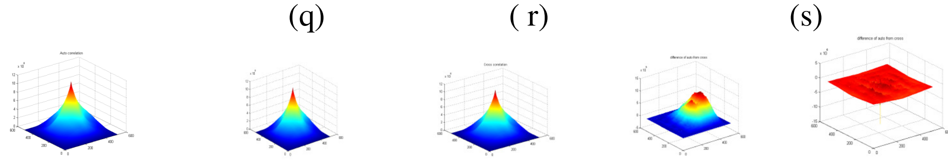


FIGURE 4: Comparison of various images from diversified fields with autocorrelation and cross correlation of the original image, degraded by Gaussian noise image with constant density, and restored image by median filtering technique.

(q) (r) (s)



(t) (u) (v) (w) (x)

FIGURE 5: Steps of Performing and evaluating the correlation quality of noisy image and Restored image, (q) “original image cameraman” (r) “image degraded by Gaussian noise” (s) “restored image” (t) “ Autocorrelation of original image” (u) “ Cross correlation of original & noisy image” (v) “Cross correlation of restored & original image” (w) “difference between u and t; (u-t) ” (x) “difference between v and t: (v-t)”

Besides testing the proposed scheme on synthetic degradations, we also applied it to real-life degraded photos. We used four different gray scale images shown in fig.6. The corresponding grayscale images were also restored by nonlinear filtering techniques. We addressed two kinds of real-life degradations: the images in fig.6.were purposely taken with the camera wrongly focused in foggy area, while original version in fig.6. The camera was rotated in vertical direction while the images being taken in foggy forest area to produce a particular noise.

(a)

(b)

(c)

(d)

FIGURE 6: Result with an actual degraded images from nonlinear restoration techniques with ISNR in dB (a) “forest ISNR= 4.07” (b) “foggy Telephone pole ISNR= 5.99” (c) “flower ISNR=3.93” (d) “foggy forest ISNR=2.23”

The images were taken with cannon camera, and were coded in JPEG format (this JPEG format convert in to tif) to process. The noise that was present in the image was quite significant. All restored images were significantly sharper and had more visible details than the noisy ones, even though they had some what a “patchy” look, corresponding to some what a piece wise constant character. As had happened with the synthetic degradations, the restoration was slightly better than noisy (real life degraded) images. The results obtained with these images were of lower visual quality than those obtained with the synthetic degradations. Two of the reasons for this probably were as follows. The noise that present in the images probably did not exactly follow the restoration method of; one of the main reason may have been the presence of nonlinearities in the image acquisition. It is known that image sensors may not be perfectly linear, due to the presence of anti-blooming circuits, for example. Furthermore, in the case of the canon camera, for which we did not have access to actual data of image, we suspect that the camera also performed some nonlinear operations like restoration, sharpening, and gamma compensation. The noise produced by charge couple device and climate condition is not synthetic Gaussian and its intensity independent from the image intensity, so that restoration technique not showing the response as to synthetic degradations.

Type of images from diversified fields	PSNR (original and noisy)/(original & restored image)	Normalized cross correlation(NCC) (original & noisy)/(original & restored image)	Absolute Difference(AD) (original & noisy)/(original & restored image)	Maximum Difference (MD) (original & noisy)/(original & restored image)	Structural content ,original / Structural content, restored
Water	20.12/25.31	1.00/.98	0.44/0.4	107/124	0.92/1
Chemical plant	20.06/24.18	0.99/.97	0.009/0.47	112/12	0.94/1.01
Man	20.35/27.29	1.00/0.99	0.97/0.03	98/73	0.94/0.99
Reso.char	22.77/21.76	0.96/0.98	8.05/1.79	108/255	1.07/1.03
Clock	20.57/25.32	0.94/0.99	0.81/0.05	111/197	0.99/1
Plane	20.33/26.75	0.99/0.99	0.35/0.11	120/203	0.98/0.99
Arial	20.13/24.05	0.99/0.98	0.22/0.52	114/130	0.97/1.01
Planet	20.03/25.94	0.99/0.99	0.02/0.34	108/149	0.96/1
Pic	20.07/25.11	1/0.99	0.25/0.06	108/126	0.95/1
Pepper	20.11/26.43	0.99/0.99	0.27/0.22	111/189	0.96/1
Liver	20.96/27.51	1.00/0.99	2.92/0.45	89/64	0.91/0.99
Circuit	20.38/26.85	1.0/0.99	0.89/0.10	97/153	0.92/0.99
Brain	21.25/26.22	1.0/0.96	3.99/0.76	93/142	0.86/1.02
Baboon	20.03/19.80	1.0/0.96	0.15/0.31	101/192	0.96/1.027
Appert	22.34/29.62	1.0/0.99	8.48/3.31	99/62	0.85/0.98

TABLE 5: Showed Differenent Distortion metrics & correlation distortion metrics computed of Original, Degraded and Restored Image: Filter; Median, Noise: Gaussian at Constant Noise Density (Standard Deviation and Mean)

6. DISCUSSION

We stress that, although our numerical results of nonlinear restoration techniques with different noises, some parameters are crucial: MSE, NMSE, and PSNR. In fact experiments have shown that the same sequence of 'σ' and numerical parameters yield considerable results for a wide range of images from diversified fields. This being said, we should note that, by considering quantitative measures, somewhat better optimum selection can be obtained without wasting time to perform experiment separately. In several practical applications, it may be quite possible to select restoration techniques to particular field images. For example, EIA pattern image with Gaussian noise, non linear restoration technique is not suitable to restore the image of EIA pattern.

The choice of restoration techniques for the diversified field images degraded by different types of noise with density is crucial for selection. The choice of restoration technique for specific noise and image has been provided for researchers, it is nothing but the optimization solution up to some extent to select the nonlinear restoration technique.

Weighted median filter with Gaussian operator is providing improved result to some images, we performed experiment with different operators with PSF. Result obtained from the same filter with different operators are less improved than with Gaussian operators, it is shown in table 5 in percentage. We can see that, with nonlinear restoration (weighted median filter) to Gaussian noise clearly surpassed the other combination to same sequence of images from various fields except for baboon image.

7. CONCLUSION

We have presented a critical performance of restoration methods for noisy images from diversified fields. The methods are handled with synthetic degradation to compute the numerical results. We have computed the quantitative measures using correlation techniques and also adapted MSE, PSNR, NMSE measures to the evaluation of restoration performance of nonlinear methods. According to restoration quality of nonlinear techniques were visually and quantitatively compared and provided optimum solution for the selection to particular image from specific field.

Experimental performance showed on a variety of images, only on gray scale, with a variety of synthetic degradation, without and with noise, generally occurs in real life degradation, and in single image at a still situation. We compared performance of nonlinear restoration methods, median filter is not efficient for resolution chart and baboon (animal face) image if encompass the Gaussian noise, efficient to medical image ‘Appert’. When Pepper & Salt noise occurs in animal facing images, median filter is not suitable. We should note that, by finding distortion measure parameters, somewhat better result obtained than once that we have shown in first combination, however efficiency for natural images more than 90% of nonlinear restoration method. Median filtering technique, Performance estimated based on correlation concept used to determine the improvement of nonlinear restoration methods, degraded by synthetic noise.

So far, whenever the degradation image has noise, the particular restoration technique has to be choosing, by selecting the nonlinear restoration technique which yields the best compromise between type of image from particular field and noise detail. An automatic selection criterion will obviously be useful. This is the direction in which further research will be done.

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9. REFERENCES

[1] T.Weissman, E.Ordentlich, G.Seroussi, S.Verdi, and M.J.Weinberger, “Universal discrete denoising: known channel,” IEEE trans. Inform. Theory, Jan. 2005.

[2] T.Weissman, E.Ordentlich, G.Seroussi, S.Verdi, and M.J.Weinberger, “A discrete universal denoiser and its application to binary image,” in proc. Of ICIP’03, Barcelona, Sept. 2003.

[3] A.Buades, B.Coll, and J.M.Morel, “A new of image denoising algorithms, with a new one,” SIAM of multiscale modeling and simulation (MMS)

[4] H.Takeda, S.Farsiu, and P.Milanfar, “Kernel regression for image processing and reconstruction,” IEEE Trans. Image Processing., Vol.16, no. 02, pp. 349-366, Feb. 2007.

[5] Ignacio Ramirez, M. Weinberger, “The dude frame work for continuous tone image denoising, ” IEEE Trans.2005.

[6] R.H.Chan, C.Ho, and M.Nikolova, “salt & pepper noise removal by noising detector and detail persening regulization,” IEEE Transon Image Processing, available at http:/www.math.cunk.edu.hk /impulse.

[7] L.Yin, et.al. “Weighted median Filter: Atutorial,” IEEE Trans on circuit and system II, Vol.43, Issue03, pp.157-192, March 1996.

[8] A.Buades, B.Cell, and J.Morel, “ A non-local algorithm for image denoising,” in Proc. IEEE Conf. Computer Vision and Pattern Recognition, Washington, DC, Oct. 2005, Vol. 02, pp. 60-65.

[9] I.Pitas, A.N.Venetsanopoulos, “Nonlinear filters principle and application,” Kluwrer Academic Publishers, Dodresht, 1990.

[10] J. Astola and P. Kuosmanen, Fundamental of Nonlinear Filtering, Boca Raton, CRC Press, 1997.

[11] A.Asensio, A.Lopez Ariste, “Image Reconstruction with Analytical Point Spread Function,” Astronomy & Astrophysics Manuscript, pp. 1-10, April 20, 2010.

[12] Y.E. Ioannidis, "The History of Histograms (Abridged)," ***Proc. Int'l Conf. Very Large Data Bases,*** 2003.

[13] S. Guha, N. Koudas, and K. Shim, "Approximation and Streaming Algorithms for Histogram Construction Problems," ***ACM Trans. Database Systems,*** vol. 31, no. 1, pp. 396-438, 2006.

[15] T. Loupos, W. N. McDicken and P. L. Allan, “An adaptative weighted median filter for speckle suppression in medical ultrasonic images,” IEEE Trans. Circuits Syst., vol. 36, Jan. 1989.

[16] L. Yin, R. Yang, M. Gabbouj, and Y. Neuvo, “Weighted median filters: A tutorial,” IEEE Trans. Circuits and Syst. II: Analog and Digital Signal Processing, vol. 43, pp. 157-192, Mar. 1996.

[17] M.D.grassberg and S.K. nayar, “modeling the space response function of camera,” IEEE trans., PAMI, vol. 26, Oct. 2004.

[18] D.Donoho, “ denoising by soft thresholding ,” IEEE, Trans IT, vol. 3, 1995.

[19] D.Martin, C. Fowlkes, D. Tal and J. Malik, “ A database of natural images and its applications to evaluating segmentation algorithms and measuring ecological statistics”, proc. IEEE conf. Computer Vision, Volume 2, pp., 416-423, July. 2001.

[20] A. stefano, P. white, “ training method for image noise level estimation on wavelet componenet,” JASP, vol. 16, 2004.

[21] J. portilla, “ blind denoising through noise covarience estimation using gaussian scale mixture in wavelet domain,” IEEE, conf Image processing, pp1217-1220, 2004.

[17] S-J. Ko and Y. H. Lee, “Center-weighted median filters and their applications to image enhancement,” IEEE Trans. Circuits and Syst., vol. 38, pp. 984-993, Sept. 1991.

[18] T. Chen, K.-K. Ma and L. -H. Chen, “Tri-state median filter for image denoising,” IEEE Trans. Image Processing, vol. 8, pp. 1834-1838, Dec. 1999.

[19] E. Abreu, M. Lightstone, S. K. Mitra and K. Arakawa, “A new efficient approach for the removal of impulse noise from highly corrupted images,” IEEE Trans. Image Processing, vol. 5, no. 6, pp. 1012-1025, Jun. 1996.

[20] E. Abreu, "Signal-dependent rank-ordered mean filters," Nonlinear Image Processing, S. K. Mitra and G. L. Sicuranza (Eds.), Academic Press, 2000.

[21] Y.L.You and M.Kaveh, "Blind image restoration by anisotropic regularization," IEEE Trans. Image Processing, vol. 8, no. 3, pp. 396-407, Mar. 1999.