A Comprehensive Study on Image Denoising with its Different Methods and Types

Pooja Pandey[1], Dr. Vineet Richhariya[2], Vikram Rajput[3]
[1, 2, 3] Department of CSE
[1, 2, 3] LNCT, Bhopal

Abstract- *Images contain several types of noises due to belonging factors. Sensor Defects, Lens Distortion, Software Artifacts, blur etc. are the belonging factors which affects the quality of images. If we want to produce the quality of the images to be higher than the belonging factors should not be ignored. There are many noise reduction techniques have been developed for removing noise and retaining edge details in images. Choice of de-noising algorithm is application dependent and depends upon the noise kind present in image. Each technique has its own assumptions, advantages and limitations. This paper present type of noise and dancing techniques.*

Keywords- Image Deniosing, Guided Filter, Wiener filter, PSNR, MSE.

I. INTRODUCTION

Denoising of an Image is a typical yet still active topic in the image processing and also low level vision, while it is an ideal test bed to estimate numerous statistical image modeling approaches. With fast digital imaging technology development, now acquired images can involve megapixels tens. On one hand, extra fine scale texture scene features will be captured; on other hand, captured high definition image is extra prone to noise because all pixel size creates the exposure less sufficient. Unfortunately, suppressing noise and preserving textures are challenging to achieve simultaneously, and this has been one of the additional challenging issue in the natural image denoising. Unlike huge scale edges, the fine scale textures are extra complex and are hard to characterize through applying a sparse model. Texture regions in an image are homogeneous and are composed of similar local patterns, which can be characterized through applying local descriptors. Applying histogram specification, a gradient histogram preservation algorithm is developed to confirm that gradient denoised image histogram is close to Reference histogram, resulting in a simple yet efficient GHP based denoising algorithm[1].

Image denoising, which goal to estimate the latent clean image x from its noisy observation y, is a typical yet still active topic in image processing and low level vision. One widely used data observation model is y = x + v, where v is AWGN. One popular approach to image denoising is the variational method, where an energy functional is minimized to search the desired estimation of x from its noisy observation y. The energy functional usually involves two terms: a data fidelity term which depends on the image degeneration process and a regularization term which models the prior of clean natural images. The statistical natural image modeling priors is crucial to the image denoising success [2].

We assume that the image acquisition method may bemodelled through following image formation model

$$z = h * u + n, \quad (1)$$

where u: $R^2 \rightarrow R$ denotes ideal undistorted image, h: $R^2 \rightarrow R$ is a blurring kernel, z is the observed image which is represented as a function $z : R^2 \rightarrow R$, and n is an additive Gaussian white noise with zero mean and standard deviation σ.

Let us denote through Ω the interval $(0,N]2$. As in most of works, in order to simplify this issue, we shall assume that functions h and u are periodic of period N in every direction. That amounts to neglecting few boundary effects. Therefore, we shall assume that h, u are functions defined in $\Omega$and, to fix ideas, we assume that $h, u \in L2(\Omega)$. Our problem is to recover as much as possible of u, from our blurring kernel h knowledge, the noise n statistics, and observed image z.

The basic problem of recovering u from z is ill-posed because of the ill-conditioning of the operator $Hu = h * u$. Numerous approaches have been proposed to recover u. Most of them can be categorized as regularization approaches which may take into account statistical properties (Wiener filters), information theoretic properties[3], a priori geometric models or the functional analytic image behavior given in terms of its wavelet coefficients.

II. TYPE OF NOISES

The noise is characterized by its pattern and with its probabilistic characteristics. There are a wide variety of noise types, while we focus on the most important types, they are; Gaussian noise, salt and pepper noise, poison noise, impulse noise, speckle noise.

A) Gaussian Noise

Gaussian noise is statistical noise that contain its probability density function equal to the normal distribution, which is also called Gaussian distribution. In other words, values that the noise can achieve on being Gaussian-distributed. A special case is white Gaussian noise, in which values at any period of times are identically distributed and also statistically independent. In applications, Gaussian noise is most usually used as additive white noise to yield additive white Gaussian noise.

(a) (b)

Figure 1.(a) original image and (b) Gaussian noise image

B) Salt And Pepper Noise

Salt and pepper noise is a form of noise classically seen on images. It represents itself as casually happening white and black pixels. An efficient noise reduction technique for this noise kind conclude the median filter usage, morphological filter or a contra harmonic mean filter. Salt and pepper noise creeps into the images in circumstances where quick transients, for example faulty switching, take place.

(a) (b)

Figure 2.(a) original image and (b) Salt and pepper noise image

C) Poison Noise

Poisson noise is induced by the nonlinear response of the image detectors and recorders. This type of noise is image data dependent. This term arises because detection and recording processes involve random electron emission having a Poisson distribution with a mean response value. Since the mean and variance of a Poisson distribution are equal, the image dependent term has a standard deviation if it is assumed that the noise has a unity variance.

(a) (b)

Figure 3. (a) original image and (b) Poisson noise image

D) Impulse Noise

Impulse noise is a category of the (acoustic) noise which conclude unwanted, almost instantaneous (thus impulse-like) sharp sounds (like clicks and pops). The noises of the kind are typically caused through electromagnetic interference, scratches on recording disks, and ill synchronization in digital recording and communication. High levels of, such a noise (200 + Decibels) may be damage internal organs, while 180 Decibels are enough to destroy or damage human ears.

(a) (b)

Figure 4.(a) original image and (b) Impulse noise image

E) Speckle Noise

Speckle is a complex phenomenon, which degrades image quality with a backscattered wave appearance which originates from many microscopic diffused reflections that passing through internal organs and creates it extra difficult for the observer to discriminate fine detail of the images in diagnostic examinations. This type of noise occurs in almost all coherent systems such as SAR images, Ultrasound images, etc. The source of this noise is random interference between coherent returns. The speckle noise follows a gamma distribution [4]. Thus, denoising or reducing the noise from a noisy image has become the predominant step in medical image processing. For the quality and edge preservation of images we have taken different denoising techniques into consideration.

(a) (b)

Figure 5.(a) original image and (b) Speckle noise image

III. DENOISING TECHNIQUE

a) Mean Filter

Mean filtering is usually used as an easier technique for decreasing noise in an image. Mean filtering is a simple, spontaneous and easy to execute method of smoothing images. The calculated median value is replaced with center value.

b) Median Filter

It provides improved impulse noise elimination from corrupted images. It replaces the center value with the median of each pixels in the window. According to window size each pixels in the window is taken and sort the pixel then find the median of the each window. Then this median value is replaced by center value.

c) Weighted Median Filter

The basic idea is to give weight to the each pixel. Every pixel is given a weight. This weight is multiply with pixel. According to this weight the pixels are sort into ascending order, and then find the median value from the sorted list. This value is replaced with center value.

d) Center Weighted Median Filter

In CWM center pixel of window is considered as test pixel. Check that the center pixel is less than minimum value available in the window and center pixel is bigger than maximum value available in window then center pixel is considered as corrupted pixel. This corrupted pixel is replaced by calculated value. Weight is given to the center pixel then sorts all element of window in ascending order and calculate median of elements.

e) Tri-state Median Filter

This will work according to the threshold value. First take each pixel from the window then check that this pixel is less than the predefined threshold value, and then this pixel is consider as uncorrupted pixel and keep the pixel as it is. Otherwise calculate CWM filter value and Standard Median (SM) value. Check that the threshold is placed between CWM and SM, and then the corrupted pixel is replaced with CWM value. If the SM is greater than threshold then the SM value is placed instead of noisy pixel. The range of threshold is 0 to 255.

f) Adaptive Median Filter

It uses changing window size to denoising. The window size is increases until get the correct value for median is calculated and noise pixel is replaced with calculated median value. Here two conditions are used one to find corrupted pixels and second one is to check accuracy of median value. Check that the pixel is less than minimum value available in window and also the pixel is greater than maximum value present in window then center pixel is considered as corrupted pixel. Then check that the median value is less than minimum pixel value available in window and median is greater than maximum pixel value available in window, then median value is judge as noisy pixel. If the median is noisy one then increase the window size and again calculate the median value of the pixel until get correct median value. While increasing the window size it will consider the previous median value also.

g) Progressive Switching Median Filter

Here one pixel is taken for test pixel from the window. Check that the pixel is less than the minimum value of the pixel available in the window and greater than the maximum value of the pixel available in the window then central pixel is considered as noisy pixel. Second noise pixels are replaced by estimated median value. Then check that the median value is less than minimum pixel value available in window and greater than maximum pixel value available in window, then median value is consider as noisy pixel. If the median is noisy one then increase the window size and again calculate the median value of the pixel until get correct median value. Here median is calculated without considering the noisy pixel available in window. Then check that the calculated median value is less than minimum pixel available in window and greater than maximum pixel available in window then median value is consider as corrupted value. If the median is noisy one then increase the window size and again calculate the median value of the pixel until get correct median value.

h) Rank-Order Based Adaptive Median Filter

In RAMF, a pixel is taken if the median of a window is placed between the minimum and the maximum value of the window and the pixel is exactingly between minimum and maximum window value; In case, the median of the window under concern is exactingly between the minimum and the maximum window value and the pixel does not lie between the minimum and the maximum value of the window, then the pixel is replaced through median value; otherwise, the window size is better and the pixel will be replaced by the median of the increased size window, also the new median is between minimum and the maximum value of the window, otherwise, the window size is again improved up to pre-fixed maximum level, otherwise the central pixel is keep unchanged.

i) Minmax Detector Based filter

The goal of this method is to restructure the true image from the corrupted image. MDB should work at high noise image and superior to other existing techniques. Here the center pixel is taken as tested pixel. Then check that test pixel is less than minimum value present in the window or test pixel is greater than the maximum value present in the window then test pixel is corrupted. If the test pixel is corrupted then find the median value apply that value to the corrupted pixel. Shift the window row wise then column wise to cover all the pixels in the image, and then continue the above checking.

j) Adaptive Rank Order Filter

Here check that center pixel is noisy or not. If yes then sort the pixels in the window in ascending order. Then find the minimum, maximum and median value .Then check that the median value is noisy one or not by checking the median is placed between min and max value, if yes med is not a noisy pixel then replace center value with median value. Otherwise expand the window size. Repeat the steps until all pixels are process.

k) Robust Estimation algorithm

First find the median, and then find the minimum value and maximum value from the selected window. Check that minimum value is less than median value and the median value is less than maximum value from the window. If the condition is true, then check that the test pixel is placed between the minimum and maximum value if it is trues then that pixel is not a noisy one. Otherwise find absolute deviation of the each pixel. If the absolute deviation is zero neighbourhood pixel is consider as corrupted one, else calculate robust influence function using this calculated value the pixel is calculate.

l) Decision Based Adaptive Median Filter

Here two stages are to remove the noise. In the first stage noise pixel is detect using rank order absolute difference. In the second stage noisy pixel is replaced by calculated median value. Find the absolute deviation for the entire pixel. Then sort the calculated absolute deviation and find the sum of the smallest absolute deviations are calculated, this is called ROAD. The ROAD value is compare with threshold. Based on this comparison the noisy pixel is identified. In the case of filtering, check that flag in the binary image is zero then that pixel is not noisily one, otherwise check that the number of non zero pixels are three or above then the pixel is replaced with median of non zero pixels. If the number of nonzero pixel is less than three then increase the initial value and do the steps from the beginning.

m) Robust Outlyingness Ratio-Nonlocal Mean filter

This case the denoising consists of two steps, detection followed by filtering. The detection contains two stages coarse and fine stage. Here the steps are same in the both stages only difference is that, in the case of coarse stage large threshold is given through this the false-hit term become small and miss term become large [5]. The output of coarse stage is given to fine stage, here in the fine stage the threshold is taken as small then the false-hit become large and miss term become small. In the detection first calculate the ROR value for each pixel then according to ROR value the pixel is divided into four clusters. Then find the absolute deviation, then compare the absolute deviation with threshold according to this comparison the noise pixel is identified. The result is added to the flag detection matrix. This detection flag matrix is given to nonlocal mean. The Nonlocal Mean is used to filter the noise from the image. It will produce visually good image with high PSNR value. Also produce excellent result and better output compare with other existing methods.

IV. LITERATURE SURVEY

Michael Elad (2006) et al present that applying K-SVD algorithm, we found a dictionary that defines image content effectively. Two different training options are considered: applying corrupted image itself, or training on high-quality image database corpus. Since K-SVD is limited in handling small image patches, and extend its deployment to arbitrary image sizes through defining a global image prior that forces sparsity over patches in all location in image[6].

Weisheng Dong (2013) et al present that models code of sparse representation an image patch as a linear combination of a some atoms chosen out from an over-complete dictionary, and present promising outcomes in numerous image restoration applications. To increase sparse representation-based image restoration performance, present sparse coding noise concept is introduced, and the image restoration aim turns to how to suppress sparse coding noise[7].

Wangmeng Zuo (2013) et al present that Natural image statistics perform significant role in image denoising, and numerous natural image priors, concluding gradient based, sparse representation based and nonlocal selfsimilarity based ones, have been extensively studied and exploited for noise elimination. The study GHP algorithm can well preserve texture, appearance in denoised images, creating them look additional natural [2].

Michal Aharon (2006) et al present that applying an over complete dictionary that include prototype signal-atoms, signals are defined through sparse linear combinations of these atoms. Designing dictionaries to enhance fit the above model can be complete through either selecting one from a prespecified linear transforms set adapting the dictionary to a training signals set. Study new algorithm for adapting dictionaries in order to achieve sparse signal representations. Given a training signals set, seek dictionary that leads to best representation for all member in this set, under strict sparsity constraints [8].

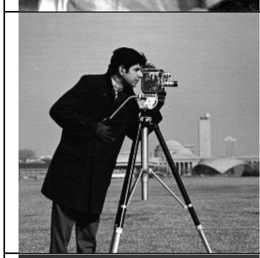
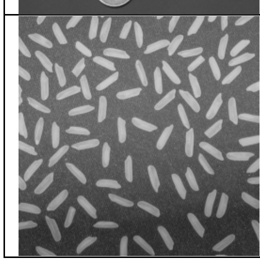
Milindkumar V (2011) et al present that Reducing noise from the medical images, a satellite image etc. is a challenge for researchers in the digital image processing. Various approaches are there for noise reduction. Generally speckle noise is commonly found in synthetic aperture radar images, satellite images and medical images. Study filtering techniques for the removal of speckle noise from the digital images. Quantitative measures are done by using signal to noise ration and noise level is measured by the standard deviation [9].

P.Mahalakshmi (2015) et al present that natural image statistics shows significant role in image denoising and numerous natural image priors, including gradient-based have been extensively studied and exploited for noise elimination.

Image denoising goals to estimation the latent clean image from its noisy observation . Using pre-processing technique with histogram equalization. In this project propose a textures enhanced image denoising technique through enforcing the gradient histogram of the denoised image to be close to a reference gradient original image histogram and to enhance the texture structures while eliminating noise[1].

Miao Zheng (2011) et al present that a graph based algorithm, known as graph regularized sparse coding, to learn sparse representations that explicitly take into account structure of local manifold of the information. Through applying graph Laplacian as a smooth operator, found sparse representations most smoothly along geodesics of the data manifold. The extensive experimental outcomes on image classification and clustering have demonstrated the efficiency of proposed algorithm[10].

Table1. Comparative Results on Different Methods

IMAGE	Guided Filter MSE	Wiener Filter MSE	Guided Filter PSNR	Wiener Filter PSNR
	25.6329	19.4256	30.5854	32.0563
	17.9980	19.7444	31.7814	31.1602
	13.2965	11.5053	33.4049	34.4053
	26.1108	22.2865	30.8855	31.5399
	40.1413	43.2788	28.2429	27.5165

This table shows that the comparison between different techniques on the basis of the peak signal noise ratio and mean square error.

V. CONCLUSION

Denoising or noise reduction has been a permanent research topic for scientists and engineers and one reason for it is the single method lack, which is able to achieve denoising for an extensive class of images. By, classical linear noise elimination methods for example Wiener filtering, has been existing for a long time for their simplicity and are able to achieve significant noise elimination when the noise variance is low, they cause blurring and smoothening of the sharp image edges. Hence, in present years there has been a fair amount of research on non-linear noise elimination methods and prominent among them are wavelet based denoising approaches.In this paper present various noise and technique of image denoising.

REFERENCES

[1] P.Mahalakshmi, J.Muthulakshmi and S.Kannadhasan,” Image Denoising To Estimate The Gradient Histogram Preservation Using Various Algorithms”, International Journal of Advance Research In Science And Engineering, IJARSE, Vol. No.4, Special Issue (01), March 2015.

[2] Wangmeng Zuo, Lei Zhang, Chunwei Song, David Zhang and Huijun Gao,” Gradient Histogram Estimation and Preservation for Texture Enhanced Image Denoising”, 2013 IEEE Transactions on Image Processing, pp:1-14.

[3] Vicent Caselles,” Total variation based image denoising and restoration”, Proceedings of the International Congress of Mathematicians, Madrid, Spain, 2006

[4] JaspreetKaur, ManpreetKaur, PoonamdeepKaur, ManpreetKaur,” Comparative Analysis of Image Denoising Techniques”, International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, Volume 2, Issue 6, June 2012.

[5] Anjali Ojha and Nirupama Tiwari,” A Study on Image Denoising with its Techniques and Types of Noise”, International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 3 Issue VIII, August 2015, pp:455- 461.

[6] Michael Elad and Michal Aharon,” Image Denoising Via Sparse and Redundant Representations Over Learned Dictionaries”, IEEE Transactions On Image Processing, Vol. 15, No. 12, December 2006, pp: 3736- 3745.

[7] Weisheng Dong, Lei Zhang, Guangming Shi and Xin Li,” Nonlocally Centralized Sparse Representation for Image Restoration”, IEEE Transactions On Image Processing, Vol. 22, No. 4, April 2013, pp: 1620- 1630

[8] Michal Aharon, Michael Elad, and Alfred Bruckstein,” K-SVD: An Algorithm for Designing Overcomplete Dictionaries for Sparse Representation”, IEEE Transactions On Signal Processing, Vol. 54, No. 11, November 2006, pp: 4311-4322.

[9] Milindkumar V. Sarode and Prashant R. Deshmukh,”Reduction of Speckle Noise and Image Enhancement of Images Using Filtering Technique”, International Journal of Advancements in Technology 2011, pp: 30- 38.

[10] Miao Zheng, Jiajun Bu, Chun Chen an Wang, Lijun Zhang, Guang Qiu, andDeng Cai,” Graph Regularized Sparse Coding for Image Representation”, IEEE Transactions On Image Processing, Vol. 20, No. 5, May 2011, pp: 1327- 1336