ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 3, March 2014

Evaluation and Comparison of Denoising Method: A Critical Review

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ABSTRACT: Image denoising is a major area of research due to the need of clear images in the field of simple photography, medical image recognition, Human Shape digitization etc. There are several process has been applied when we will work with images like receiving, transforming, coding and decoding. So the chances of noise to be inserted in the real images are high. Our motivation of this paper is to study and highlight the approaches which has been discussed and analyzed earlier. Based on our study we will suggest some better methodology with the loop area where we can apply some method for better noise reduction. Our analysis shows several loop areas where the work will be done in future for better denoising. We also discuss support vector machine(SVM), Partial differential equation(PDE), wavelet based denoising techniques with their flaws and merit and find some future insights also.

KEYWORDS: Image Denoising,PDE,SVM, Wavelet Transformation

I.INTRODUCTION

In faith, the image will certainly be distinct with a dictatorial number of noises. The noise will dwindle the ambience of the images, in feigning to provide with the bolstering to a higher stability, it is supreme to deal with image noise.During the sustain decades, a number of avant-garde methods based on wavelet transforms undertaking emerged. Such as: Mallat's professed wavelet denoising overtures based on wavelet transform maximum principle [1]. Xu and others put forward wavelet denoising methods based on wavelet transform scale correlation between the wavelet coefficients [2].Donoho and others put forward soft-threshold and hard- threshold wavelet denoisingmethods [3][4][5]. Due to the simple and effective algorithm, wavelet denoising methods based on hard-threshold and soft-threshold are widely used.

Denoising algorithm mainly used for achieving the correct image without any noise. There are several methods and algorithms are presented on image denoising problem [6] [7] [8][9] [10] [11]. For instance, several authors applied different techniques for improving image denoising results and make better image retrieval system by applying PSNR and SNR ratio.

There are several algorithms which are proposed and analyzed, such as algorithms based on wavelet transform [12] [13] [14], algorithm based on spatial filters [15] and algorithm based on fuzzy theory [16]. In [17] and [18] the authors used the method of least squares support vector machines and image decomposition respectively. Later, some researchers proposed an algorithm using non-aliasing contour let transform [19] and partial differential equation [20]. Empirical mode decomposition (EMD) was firstly proposed by Huang [21]. EMD is mainly used to one dimension signals processing, such as sound signals. Later, bi-dimensional empirical mode decomposition (BEMD) was used to image signal processing [22] [23] [24]. In [25][26] author proposed the algorithm using partial differential equation & bi-dimensional empirical mode decomposition. They execute BEMD to original image and get the intrinsic mode functions (imfs) and residue. Secondly, we filter noise of the imfs with partial differential equation (PDE). The particle filter is combined with Kalman filter to form a new image denoising framework which is presented in [27].An accurate proposal distribution is computed by using conditionally Gaussian state space models and Rao-Blackwellized particle filtering by the authors. Their improved filter is very effective in eliminating noise in real noisy images. Their Experimental results carried out with real noisy digital mobile camera images and RBPF is compared with particle filter. In terms of noise removal RBPF outperforms for

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degraded mobile camera images. So there are several denoising techniques had been applied till now but in terms of improvement the work is going on for better noise removal. Our paper is dedicated to survey in the same direction for finding the new insights.

We provide here a brief survey on Denoising Method. Other sections are arranged in the following manner: Section 2 describes about Literature Review; Section 3discusses about problem domain; section 4 shows the analysis; Section 5 describes Conclusions and future work.

II.LITERATURE REVIEW

In 2008, M. A. AlAttar et al. [28] examined the performance of different classification techniques. They uses numericalsimulation for quantitatively evaluate theperformance of each technique. They shows that the Bayes classifier is the best in terms of sensitivity, specificity and precision. Nevertheless, the Bayes Classifier takes longer
Computation time than the other techniques; they can sacrifice with the time factor to get better performance. That is, the computation time is the price paid for optimal noise removal.

In 2009, Li Hongqiao et al. [29] suggest that wavelet image denoising has been widely used in the field of image noise. They resent a new image denoising method. In this approach they first decomposes the noisy image in order to getdifferent sub-band image. Then they remain the low-frequency wavelet coefficients unchanged, and after taking into account the relation of horizontal, vertical and diagonal high-frequency wavelet coefficients and comparing them with Donoho threshold, they make them enlarge and narrow relatively. Then they use soft-threshold denoising method to achieve image denoising. Finally, they get the denosing image by inverse wavelet transform. According to their result of experiment, their method compared to soft-threshold denosing method has a higher PSNR and visual effects.

In 2011, V.NagaPrudhvi Raj et al. [30] suggest Medical diagnosis operations such as feature extraction and object recognition will play the key role. These tasks will become difficult if the images are corrupted with noises. So the development of effective algorithms for noise removal became an important research area in present days according to the authors. They proposed denoising method which uses Undecimated Wavelet Transform to decompose the image and we performed the shrinkage operation to eliminate the noise from the noisy image. In the shrinkage step they used semi-soft and stein thresholding operators along with traditional hard and soft thresholding operators and verified the suitability of different wavelet families for the denoising of medical images. Their results proved that the denoised image using UDWT (Undecimated Discrete Wavelet Transform) have a better balance between smoothness and accuracy than the DWT. We used the SSIM (Structural similarity index measure) along with PSNR to assess the quality of denoised images.

In 2012, R. Harrabi et al. [31] analyzed the ineffectiveness of isotropic and anisotropic diffusion and extended the work into the regular anisotropic diffusion. Isotropic diffusion is used at locations with low gradient and total variation based diffusion is used along likely edges. These denoising techniques have been applied to textured and satellite images to illustrate the methodology. The PSNR for the test data available is evaluated and the classification accuracy from these denoising techniques is validated. Their experimental results demonstrate the superiority of the regular anisotropic diffusion for image denoising.

In 2012, Guo-Duo Zhang et al. [32] suggest that the purpose of image denoising is obtained from the degraded image noise removal, restore the original image. Traditional denoising methods can filter noise, but at the same time they make the image details fuzzy. The support vector machine based method for image denoising is a good method, thus it can not only wipe of noise, but also retain the image detail. Support vector machine is a machine learning, which based on statistical learning theory, and this method is widely applied to solve classification problems. Their paper proposes an image denoising method based on support vector regression. Their simulation results show that the method can save the image detail better, restore the original image and remove noise.

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International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

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Vol. 3, Issue 3, March 2014

In 2012, Liu Jinping et al. [33] propose an image sequences (video) denoising method based on image temporal-spatial GSM (Gaussian Mixture Scales) modeling in Curvelet transformation. Firstly, we construct the Bayesian Least Squared GSM (BLS-GSM) based image denoising model from single image and obtain the optimal coefficient estimation of the uncontaminated image coefficients based on this model in the curvelet domain. Then, they carry out a novel spatial-temporal joint based image noise removing method by combining the single image based denoising model with a weighted impact factor conducted on the sequential images based on the relativity of the image coefficients among the image sequences. This new image denoising method is capable of achieved higher reconstruction quality while protecting more image details. Their Experimental results from the real engineering application validate the effectiveness of our method from a series of froth image sequences processing.

In 2013, Andre Mouton et al. [34]investigates the efficacy of several popular denoising methods in the previously unconsidered context of Computed Tomography (CT) baggage imagery. Authors suggest that the performance of a dedicated CT baggage denoising approach (alpha-weighted mean separation and histogram equalisation) is compared to the following popular denoising techniques: anisotropic diffusion; total variation denoising; bilateral filtering; translation invariant wavelet shrinkage and non-local means filtering. Their study yields encouraging results in both the qualitative and quantitative analyses, with wavelet thresholding producing the most satisfactory results. Their results serve as a strong indication that simple denoising will aid human and computerised analyses of 3D CT baggage imagery for transport security screening.

In 2013, Elena Anisimova et al. [35]deals with image denoising based on the wavelet transform realized by Mallat algorithm and À trous algorithm. The effectiveness of global and subbandthresholding techniques are studied on multimedia and astronomical images contaminated by Gaussian noise. Their Experimental results on several testing images are compared with each other from two objective quality aspects (PSNR, RMSE). Astronomical image denoising techniques differ from those used for multimedia images, because astronomical data are processed by computers and are not evaluated by humans. They show especially the difference between quality criteria related with both types of images after denoising.

In 2013, Jignasa M. Parmar et al. [36]have evaluated and compared performances of modified denoising method and the local adaptive wavelet image denoising method. These methods are compared with other based on PSNR (Peak signal to noise ratio) between original image and noisy image and PSNR between original image and denoised image. Their Simulation and experiment results for an image demonstrate that RMSE of the local adaptive wavelet image denoising method is least as compare to modified denoising method and the PSNR of the local adaptive wavelet image denoising method is high than other method. Therefore, the image after denoising has a better visual
effect.

III.PROBLEM DOMAIN

In [21]they get higher PSNR through using their methodology of wavelet transform than the soft-threshold method. Greater PSNR value is, the better the image quality is as shown in table 1. But better expansible proportion of wavelet coefficients in order to get better denoising effects is missing.

Table 1: PSNR Comparison [21]

Method	**Cameraman** $\sigma = 0.007$ $\sigma=0.01$	**Barbara** $\sigma = 0.007$ $\sigma=0.01$
Original Image	22.08 20.42	21.62 20.12
Soft-threshold	24.43 23.48	25.37 24.53
Proposed Method[21]	25.65 24.44	26.29 25.15

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International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

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In [26] authors provide a comparison based on three different noise parameters and improves the SNR ratio, which reduces the noise and blur. The parameters which are considered by the authors are very limited, so the noise reduction may effect.

Table 2: Result Analysis [26]

Noise Parameter	Image with Noise	Mean Filter	PDE	BEMD and PDE	Proposed PDE[26]
Leena (10)	14.7	18.5	19.5	21.1	23.5
Cameraman(15)	10.4	15.4	17.2	19.7	23.5
Cameraman(8)	19.6	19.9	21.1	23.1	24.1

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Table 3: Result Analysis [26]

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Cameraman(8)	19.6	19.9	21.1	23.1	24.1

In [27] authors present experiments on digital mobile camera images corrupted by Gaussian noise. The performances in terms of PSNR, MSE and NAE for particle filter and RBPF methods are given in Table 4, Table 5 and Table 6.

Table 4: PSNR Values for Denoised Mobile Camera Images of Different Estimated Gaussian Noise Levels [27]

Images	**Noise Level**	**(PF)**	**RBPF**
image1	2.7688	36.7860	43.4523
image2	3.5799	35.7464	43.3326
image3	6.9420	33.7037	42.0282
image4	2.9977	35.5554	42.2365
image5	2.1333	36.6375	43.3472

Table 5: MSE Values for Denoised Mobile Camera Images of Different Estimated Gaussian Noise Levels [27]

Images	**Noise Level**	**PF**	**RBPF**
image1	2.7688	1.3884	0.6851
image2	3.5799	1.6511	0.7023
image3	6.9420	2.1861	0.8305
image4	2.9977	1.7328	0.7920
image5	2.1333	1.4453	0.7320

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 3, March 2014

Table 6: NAE Values for Denoised Mobile Camera Images Of Different Estimated Gaussian Noise Levels[27]

Images	Noise Level	PF	RBPF
image1	2.7688	0.0234	0.0117
image2	3.5799	0.0280	0.0120
image3	6.9420	0.0366	0.0140
image4	2.9977	0.0369	0.0173
image5	2.1333	0.0316	0. 0146

But they suggest performance evaluation forRao-Blackwellized particle filters.

In [32] authors experimental procedures to imagedenoising based on Support Vector Machines is presented. In addition, they use the calling function in the aboveprocedure, which is an evaluation function PSNR (the value that the bigger the better) used to calculate the standard of theimage denoising[32].
They achive the following results:
PSNR1 = 8.2237
PSNR2 =8.3217
Elapsed time is 381.828000 seconds.
time =381.8280

But decomposition can be applied for dividing the image into a set of blocks and transforming the data into the wavelet domain. An adaptive thresholding scheme based on edge strength is used to effectively reduce noise while preserving important features of the original image.

In [36] the method given in paper does not preserve edges of images while denoising the image. So the need of image denoising method based on wavelet transforms to preserve edges.

IV.ANALYSIS

After studying several research papers we come with the following analysis:

1) Reduction of noise can be considered with other parameters like Blur and also with the type of noise separation can be done.
2) Image denoising method based on wavelet transforms to preserve edges.
3) The decomposition is performed by dividing the image into a set of blocks and transforming the data into the wavelet domain.
4) An adaptive thresholding scheme based on edge strength is used to effectively reduce noise while preserving important features of the original image.
5) Themethod can besuitable for different classes of images contaminated by Gaussian noise.
6) PSNR values will be calculated with different attributes of different size images.
7) Optimization can be applied to reduce the noise level like particle swarm optimization, ant colony optimization etc.
8) Data Mining can be applied for separation based on subset superset approach for classifying according to noise level [37][38].
9) Noise based clustering can be applied so that reduction of noise can be distributed and easily reduced.

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Vol. 3, Issue 3, March 2014

V.CONCLUSION AND FUTURE SUGGESTIONS

In this paper we survey and analyze different denoising techniques used in the previous techniques as well as analysis. We also discuss the merits and some of the findings which will be incorporated to improve the noise reduction and improve the performance. Based on our study we will suggest an image denoising method based on wavelet transforms to preserve edges.The decomposition is performed by dividing the image into a set of blocks and transforming the data into the wavelet domain. An adaptive thresholding scheme based on edge strength is used to effectively reduce noise while preserving important features of the original image.

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