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A Survey of Various Image De-noising Techniques

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Abstract-

The image processing is the technology through which information of image get processed . the noises are the extra pixels which get added on the image to reduce image quality. The authors proposed various techniques which works to remove noisy pixels from the image. In this paper, various image de-nosing techniques has been reviewed and discuss in terms of their outcomes.

Keywords- Noise, De-noising, PSNR, MSE, Image Quality.

I. INTRODUCTION

A method which is used to transform an image into digital form and applied some operations on it is called an image processing. As a result, get an improved image of better quality or to take out some important information from it. The process in which input is image i.e. video frame and photograph and output may be image or characteristics associated with that image are a type of signal

processing system set signal rules to the two dimensional images. Image Processing forms core research area within engineering and computer science disciplines too. It is one of the most important application and field of research area. Visual information transmitted in the form of digital images is becoming a major method of communication in the modern age, but the image obtained after transmission is often corrupted with noise. Noise is an unwanted signal incorporated in an image during acquisition and can deteriorate human annotation and computer aided analysis of images. It adversely effects MSE and PSNR of an image. Therefore, de noising should be performed to improve the image visual quality for more accurate diagnosis. Various ways to de noise an image or a set of data exists. In general, image de noising imposes a compromise between noise reduction and preserving significant image details. The basic feature of a good image de noising technique is that it will remove the noise and at the same time maintain the visual quality by preserving the edges.

A. Image De-noising techniques

Denoising is a long standing problem with techniques too numerous to list in this exposition. While not complete, the list of approaches we present here is intended to give the reader a feeling for the diversity of existing methods.

1) Linear Filters: To remove particular type of noise, linear function is used. Averaging filters or Gaussian are suitable for this purpose. These filters are used to blur the sharp edges, destroy the lines and other fine details of image, and perform badly in the presence of signal dependent noise.

2) Non-Linear Filters: Weighted median, rank conditioned, relaxed median, rank selection are types of non-linear median filter which are developed to overcome the shortcoming of linear filter.

3) Different Type of Linear and Non-Linear Filters: Mean Filter: The mean filter is a type of simple spatial filter. It is a sliding-window filter. It replaces the center value in the window. It also replaces with the average mean of all the pixel values in the kernel or window. The window is usually square but it can be of any shape

Advantages:

a. It is very easy to use.
b. It can be used to improve impulse noise.

Disadvantages: Some details are removes of image with using the mean filter. So sometimes it does not preserve actual image.

Median Filter: Median Filter which is based on order statistics is a simple and powerful non-linear filter. It is type of soothing image. Median filter is used for reducing the amount of intensity variation between one pixel and the other pixel. In this filter, value is not replacing the pixel value of image with respect to neighbor pixel but it is replaced with the median value. Then the median is calculated by first sorting all the pixel values into ascending order and then replace the pixel being calculated with the middle pixel value. The median filter gives best result when the impulse noise been developed for the better results.

Wiener Filter:The main aim of this filter is to reduce that noise which is caught as corrupted signal. This algorithm is an early approach to digital image de-noising, invented at a time when the cost of computations was much higher than today. Still, the algorithm has become quite popular and can be executed in Matlab using the wiener2

function. The goal of wiener filter is reduced the mean square error as much as possible. This filter is capable of reducing the noise and degrading function.
4) Total variation :The intuition behind image de-noising based on total variation is that noisy images have a larger discrete image gradient than noise-free images. In other words, noisy images look grainy, whereas clean images tend to be smooth. Hence _nding an image that is smooth according to some measure but is close to the original noisy image should yield good de-noising results.
5) SSS-Based De-noising Algorithm for Gaussian noise: Sequence to sequence similarity is divided into two approaches: Pixel to pixel similarity and Block to block similarity. In PPS, the nearer the position of a surrounding pixel is to the central pixel, the more similar the value of the surrounding pixel is to the central pixel. Hence, we can use the surrounding pixel values with different weights to reconstruct the center pixel. Since PPS take into consideration only position information while discarding intensity difference researchers develop new de-noising algorithm based on BBS. It scans the entire image and finds all the blocks which show high similarity to the current processing block. Then, using their similarity values as weights, this information is used to perform the de-noising task.
6) Sparse representation based on vector extension of reduced quaternion matrix: Sparse representations of signals have drawn considerable interest in recent years. They have been proven as an effective model for image representation. An image signal can be represented as a sparse linear combination of atoms by using a specific dictionary. The dictionary can be pre-defined as a basis such as wavelets, multiscale geometric transformations ,Laplacian pyramid, curvelets, bandlets, and contourlets However, there are very few works on the sparse representation model for colour images. The traditional sparse models treat red green-blue (RGB) channels as three independent grey images and process them in a monochrome way. These models can lose the inter-relationship among the multiple channels which is to produce hue distortions in the reconstruction results. A colour image does not represent a scalar, so it is natural to define the chromatic information as vector-valued. Fortunately, quaternion algebra provides an elegant mathematical tool to deal with vector signals. Quaternion algebra is first proposed by Hamilton , which is very important and useful for computer vision and pattern recognition. The major difference between quaternion matrix and reduced quaternion matrix (RQM) is the multiplication rules. The quaternion matrix is non-commutative, but the RQM is commutative. So the RQM is simpler than the quaternion matrix. Owing to this property, a novel vector sparse representation model for colour images based on reduced quaternion algebra is proposed in this paper. The sparse reduced quaternion coefficients and the learned reduced quaternion dictionary are used to construct the colour image blocks.
7) BLS-GSM and other wavelet-based methods: Many image de-noising approaches perform de-noising on a wavelet decomposition of the noisy image. Wavelet decompositions have the desirable property of locality both in space and in frequency, which is not the case for other transforms, such as the Fourier transform. Wavelet based de-noising algorithms are based on the following steps. First, an image is transformed into a wavelet domain. Next, de-noising is effected on the wavelet coefficients, and finally the de-noised image is obtained by applying the inverse wavelet transform on the de-noised wavelet coefficients. i) Dictionary-based methods: Several de-noising algorithms rely on "dictionaries" for de-noising image patches . It is usually assumed that an image x is corrupted with AWG noise:

$$y = x + n$$

De-noising is performed patch-wise: Each patch of size k x k (with k usually between 8 and 12) is de-noised separately and inserted into the de-noised image. Usually, averaging is performed in areas of overlapping patches.
8) Anisotropic diffusion: Anisotropic diffusion is an iterative procedure based on smoothing that can be used for image de-noising. The method attempts to fulfill the following requirements: (i) Object boundaries should be preserved, and (ii) noise should be efficiently removed in homogeneous (at) regions. Images can be considered to consist of regions (e.g. one region per object), in which case the goal of anisotropic diffusion is to preferentially perform smoothing within regions rather than between regions. The name of the procedure comes from the fact that it bears mathematical similarities to heat diffusion equations and from the fact that the diffusion or smoothing process is not performed uniformly over the whole image: Smoothing adapts to the image content.
9) Block matching 3 dimensional algorithm: The BM3D filter exploits a specific nonlocal image modeling [5] through a procedure termed grouping and collaborative filtering. Grouping finds mutually similar 2-D image blocks and stacks them together in 3-D arrays. Collaborative filtering produces individual estimates of all grouped blocks by filtering them jointly, through transform-domain shrinkage of the 3-D arrays (groups). In doing so, BM3D relies both on nonlocal and local characteristics of natural images,.If these characteristics are verified, the group enjoys correlation in all three dimensions and a sparse representation of the true signal is obtained by applying a decorrelating 3-D transform on the group.

II. LITERATURE SURVEY

In 2009 Zhou, Jianzhong Cao, Weihua Liu "Contourlet-based image denoising algorithm using adaptive windows,"Contourlet is a new effective signal representation tool in many image applications. In this paper, a contourlet-based image de-noising algorithm using adaptive windows which utilizes both the captured directional information by the contourlet transform and the intrinsic geometric structure information of the image is proposed. In order to utilize both the captured directional information by the contourlet transform and the intrinsic geometric structure information of the natural images, they propose the adaptive windows which can estimate the signal variance more accurately than other windows, and then the local Wiener filtering in the contourlet domain is proposed to de-noise the noisy image. Experiments show that proposed algorithm can obtain higher peak signal-to-noise ratio than other subsampled contourlet-based image de-noising algorithms[14]. In 2012 Joachimiak, Rusanovskyy, Hannuksela,Gabbouj,"Multiview 3D video denoising in sliding 3D DCT domain". In this paper a multiview video de-noising method is proposed. Due to correlation between views in multiview 3D video at the same temporal location, it is possible to perform video processing operations more efficiently comparing to regular 2D video. In order to improve de-noising performance for multiview video, an algorithm based on de-noising in 3D DCT domain is proposed. Its performance is comparable with state-of-art algorithms and is suitable for real time applications. The proposed algorithm searches for corresponding image patches in temporal and inter-view directions, selects 8 patches with lowest dissimilarity measure, and performs de-noising in 3D DCT domain. Numerical complexity is much lower than since only one patch matching step and no Wiener filtering are used. Experimental results showed substantial improvement over the existing video de-noising method . Gains up to 1.62 dB in terms of average luma PSNR were observed, with average gain from 0.6 to 0.8 dB, depending on the magnitude of noise used to corrupt test sequences[2].In 2013 Hagawa, R.;Kaneko, S.; Takauji, H., "Using Extended Three-valued Increment Sign for a de-noising model of high-frequency artifacts in JPEG images by estimation of specific frequency". Author presented a robust de-noising model for high-frequency artifacts resulted by compressing images into JPEG. a high-frequency artifact estimation algorithm that does not rely on smoothing, but is based on evaluation of similarity using an Extended Three-valued Increment Sign (ETIS) technique. ETIS represents the relationship of adjacent pixels, which one is brighter or almost the same. In ETIS a threshold value to define the range for an 'unchanged' category for semi-quantitative evaluation of noise amplitude is introduced.The authors expected that ETIS difference between Compressed Image and Noise Image would be small except edge region. Then they find out the sum of the squares of those differences and utilized it in noise estimation. Only quantization process cause the artifacts, then they optimized DCT coefficient matrix in non-linearly based on ETIS, and estimated high-frequency artifacts as an independent approach without smoothing process. In the result, the model succeeded to reject noise with preservation of edge information[3].In 2013 Kaimal, Manimurugan, Anitha, "A modified anti-forensic technique for removing detectable traces from digital images,". The increasing attractiveness and trust on digital photography has given rise to new acceptability issues in the field of image forensics. There are many advantages to using digital images. Digital cameras produce immediate images, allowing the photographer to outlook the images and immediately decide whether the photographs are sufficient without the postponement of waiting for the film and prints to be processed. It does not require external developing or reproduction. Furthermore, digital images are easily stored. No conventional "original image" is prepared here like traditional camera. Therefore, when forensic researchers analyze the images they don't have access to the original image to compare. Fraud by conventional photograph is relatively difficult, requiring technical expertise. Whereas significant features of digital photography is the ease and the decreased cost in altering the image. Manipulation of digital images is simpler[9].In 2014 Peixuan Zhang,“A New Adaptive Weighted Mean Filter for Removing Salt-and-Pepper Noise”, In this paper to detect and remove high level of salt and pepper noise, adaptive weighted mean filter has been proposed. First of all size of the adaptive window is decided to extend the window size until two successive window become equal. After that current pixel is regarded as noise candidate if values of maximum and minimum value otherwise regarded as noise free pixel. Moreover noise candidate is replaced by the weighted mean of the current window and noise free pixel remains unchanged. Experimental results show that proposed filter has low rate detection error rate and high restoration quality for high level noise [4].In 2015 Karen Panetta, Long Bao, Sos Agaian, ’’Sequence to sequence similarity based filter for image de-noising’’. In this paper, a new concept of sequence-to-sequence similarity is introduced. This similarity measure is an efficient method to evaluate the content similarity for images, especially for edge information. The approach differs from traditional image processing techniques, which rely on pixel and block similarity. Based on this new concept, a new sequence-to-sequence similarity (SSS) based filter for image de-noising has introduced. The new SSS-based filter utilizes the edge information in the corrupted image to address image de-noising problems. They demonstrate the filter by incorporating it into a new SSS-based image de-noising algorithm to remove Gaussian noise[13].

In 2015 Bora Jin, Su Jeong You and Nam Ik Cho“Bilateral image de-noising in the Laplacian subbands”. In this paper propose an image de-noising algorithm, which applies bilateral filtering (BLF) in the Laplacian subbands. It is noted that the subband images have wider area of photometric similarity than the original, and hence, they can be more benefited by the BLF than the original [1].In 2015 Huanjing Yue’’ Weighted Joint Sparse Representation for Removing Mixed Noise in Image”. In this paper, they explained that single image de-noising is suffering from lower data collection. In this paper they explore both internal and external correlations of the web pages with the proposed image de-noising scheme. Data cubes of each patch of noise and web pages have been built for each internal and external noise patches. They have proposed two stage strategy using different filtering approaches. In first stage graph based optimization is proposed to improve accuracy in external de-noising. Preliminary result can be obtained by combining internal and external de-noising patches. In the second stage, they propose reducing noise by filtering of external and internal cubes, respectively, on transform domain. The final de-noise image is obtained by fusing the external and internal filtering results. Experimental results show that proposed technique gives best results for subjective and objective image[11]. In 2016 Licheng Liu,” Weighted Couple Sparse Representation With Classified Regularization for Impulse Noise Removal”, Joint Sparse Representation (JSR) has indicated incredible potential in different image processing and PC vision tasks. All things considered, the conventional JSR is delicate to anomalies. This paper proposes a weighted JSR (WJSR) model to at the same time encode an arrangement of data samples that are drawn from the same subspace however corrupted with commotion and anomalies. This model is attractive to misuse the normal information shared by these data samples while lessening the impact of anomalies. To illuminate the WJSR model, the strategy further presents a greedy algorithm called weighted synchronous orthogonal matching pursuit to proficiently rough the global optimal arrangement. At that point, the WJSR is connected for mixed commotion evacuation by jointly coding the grouped nonlocal comparative image patches. The de-noising execution is further enhanced by joining it with the global earlier and the sparse mistakes into a brought together framework[12].In 2016 Shan Gai, Long Wang, Guowei Yang, Peng Yang," Sparse representation based on vector extension of reduced quarternion matrix for multiscale image de-noising''. In this paper, a novel colour image sparse representation model based on RQM has presented. The colour image is described as a RQM by the proposed model. In the training state, k-means clustering RQM value decomposition is presented which makes sparse basis selection in quaternion space. Then, a reduced quaternion-based orthogonal matching pursuit algorithm is presented in the sparse coding stage. The proposed colour image sparse representation model is applied to colour image de-noising in order to demonstrate the superior performance[7].

Table I of Comparison

AUTHOR	YEAR	TITLE	RESULT
Zuofeng Zhou, Jianzhong Cao, Weihua Liu	2009	Contourlet Transform with Adaptive Windows	Achieved better performance than current subsampled contourlet based image de-noising algorithms
Joachimiak,Rusanovskyy, Hannuksela, Gabbouj.	2012	De-noising in 3D DCT Domain	Up to 1.62dB gain in terms of average luma Peak Signal-to-Noise Ratio(PSNR)
Kaimal, Manimurugan, Anitha.	2013	Anti-forensic technique	Remove the signature traces of filtering
Hagawa, Kaneko, Takauji.	2013	Simple evaluation value named Extended Three-valued Increment Sign (ETIS)	The model succeeded to reject noise with preservation of edge information
Peixuan Zhang,Fang Li	2014	A New Adaptive Weighted Mean Filter for Removing Salt-and-Pepper Noise	Achieved very low detection error rate and high restoration quality especially for high-level noise.
Karen Panetta, Long Bao, Sos Agaian,	2015	Sequence –to-sequence similarity based filter	In the PSNR tests, when the level of Gaussian noise is smaller than 30, the PNLM has the largest PSNR values, indicating the best de-noising performance.
Jin	2015	Bilateral image de-noising in the Laplacian subbands	Experimental results show that the proposed de-noising method provides higher PSNR than the original BLF and other multi-resolution de-noising algorithms. Since the high band image is also effectively de-noised in this process, the sharpened image by high band modification is also visually more pleasing when compared with the results of the conventional sharpening methods.
Huanjing Yue, Xiaoyan Sun, Jingyu Yang, Feng Wu.	2015	Image de noising by exploring internal and external correlations	Experimental results show that proposed method constantly outperforms state-of-the-art de noising schemes in both subjective and objective quality measurements, e.g., it achieves >2 dB gain compared with BM3D at a wide range of noise levels.
Licheng Liu, Chun Lung Philip Chen, Yuan Yan Tang, Yicong Zhou	2016	Weighted Couple Sparse Representation With Classified Regularization for Impulse Noise Removal	Achieved better performance in reduction of IN compared with several state-of-the-art de-noising algorithms with respect to both the quantitative measurements and the visual effects.
Shan Gai, Long Wang, Guowei Yang, Peng Yang	2016	Sparse representation based on vector extension of reduced quaternion matrix for multiscale image de-noising	The experimental results shows that the elapsed time for RQM-KSVD is less than the elapsed time for GSM, KSVD, I-KSVD, and QSVD.

III. CONCLUSION

In this paper, it is been concluded that noise are the extra pixels which get added to the original image to reduce its quality. The image de-noising is the technique which is applied to remove noisy pixels from the image. In this paper, various image de-noising techniques as bee reviewed and discussed. It is been analyzed that sparse matrix representation is the most efficient technique to de-noise the original image from the original image.

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REFERENCES

[1] Bora , Su Jeong You, Nam Ik Cho “Bilateral image de-noising in the Laplacian subbands” in signal, image and speech processing Springer International Publishing. 2015.

[2] Joachimiak, Rusanovskyy, Hannuksela, Gabbouj, "Multiview 3D video de-noising in sliding 3D DCT domain," Signal Processing Conference (EUSIPCO), 2012 Proceedings of the 20th European ., vol.20, pp.1109,1113, 27-31, Aug. 2012.

[3] Hagawa, R.; Kaneko, S.; Takauji, H., "Using Extended Three valued Increment Sign for a de-noising model of high-frequency artifacts in JPEG images by estimation of specific frequency," Frontiers of Computer Vision, (FCV), 2013 19th Korea-Japan Joint Workshop on , vol., no., pp.164,169, Jan. 30 2013-Feb. 1 2013.

[4] Peixuan Zhang and Fang Li, “A New Adaptive Weighted Mean Filter for Removing Salt-and-Pepper Noise”, *IEEE Signal Processing, vol. 21, no. 10, October 2014*

[5] Zhenwei Miao and Xudong Jiang, “Weighted Iterative Truncated Mean Filter”, *IEEE Transaction on Signal Processing, vol. 61,no. 16, August 15, 2013*

[6] Fang Li, “Salt and Pepper Noise Removal by Adaptive Median Filter and Minimal Surface Inpainting”, Image and Signal Processing, 2009. CISP '09 2nd International Conference on, 2009

[7] Shan Gai, Long Wang, Guowei Yang, Peng Yang,” Sparse representation based on vector extension of reduced quarternion matrix for multiscale image denoising’’,2016 *IEEE Transaction on image processing.*

[8] Shuqun Zhang and Mohammad A. Karim, “A new impulse detector for switching Median filters*”, IEEE signal process. Lett, vol.9, no.11, pp. 360-363, Nov.2002*

[9] Kaimal, Manimurugan, Anitha, "A modified antiforensic technique for removing detectable traces from digital images," Computer Communication and Informatics (ICCCI), 2013 International Conference on , vol., no., pp.1,4, 4-6 Jan. 2013.detection for extremely corrupted images*,” IEEE Trans. Image Process., vol. 15, no. 6, pp. 1506–1516, Jun.2006.*

[10] How-Lung Eng, Kai-Kuang Ma, “Noise adaptive soft-switching median filter*,” IEEE Trans. Image Process., vol. 10, no. 2, pp. 242–251, Feb. 2001.*

[11] Huanjing Yue, Xiaoyan Sun, Jingyu Yang, Feng Wu, “Image Denoising by Exploring External and Internal Correlations”, *IEEE Transactions on Image Processing, vol. 24, no. 6, June 2015*

[12] Licheng Liu, Long Chen, C. L. Philip Chen, Yuan Yan Tang, and Chi Man Pun,” Weighted Joint Sparse Representation for Removing Mixed Noise in Image”, 2016, IEEE Transactions on Cybernetics.

[13] Karen Panetta, Long Bao, Sos Agaian,” ’’Sequence to sequence similarity based filter for image denoising’’2015, IEEE Transactions on Image Processing.

[14] Zuofeng Zhou; Jianzhong Cao; Weihua Liu, "Contourlet-based image denoising algorithm using adaptive windows," Industrial Electronics and Applications, 2009. ICIEA 2009. 4th IEEE Conference on , vol., no., pp.3654,3657, 25-27 May 2009.

