International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869 (O) 2454-4698 (P), Volume-3, Issue-7, July 2015

Mixed Noise Removal Using Wavelet Transform With Dictionary Method

Bincy Baby, Soumya D S

***Abstract*— The image denoising is a major problem in the field of image processing. Mixed noise is the combination of Additive White Gaussian Noise (AWGN) and impulse noise (IN). Mixed noise removal from the natural image is difficult task. Many mixed noise removal methods developed so far uses two separate steps. i.e. first detect the impulse noise pixels and then remove the noise. In this work, a method is proposed that uses wavelet transform along with dictionary method. There is no explicit impulse detection step and can process AWGN and IN simultaneously. It achieves very good result for mixed noise removal. Wavelet techniques are very effective for mixed noise removal, because of its ability to capture the energy of a signal in few energy transform value. In this paper, Discrete Wavelet Transform (DWT) and followed by KSVD algorithm and weighted encoding dictionary approach is proposed. The experimental result shows that denoised image has high PSNR value for mixed noise and the quality of image is very well.**

***Index Terms*—Dictionary method, Mixed Noise, KSVD algorithm, Discrete wavelet Transform**

I. Introduction

Image is corrupted by noise during acquisition or transmission. Denoising means recovery from noise, ie reconstruct a signal from noisy one. Noise is a major problem in the field of image processing. In image, denoising techniques are used to eliminate noise retaining their important signal details such as edges and texture. In otherwise denoising is the process of removing unwanted noise in order to restore the original image. Two types of the noise can be present in the images, namely Additive White Gaussian Noise (AWGN) and impulse noise (IN). In AWGN, each pixel value is characterized by a zero mean distribution.

AWGN is occurred by motion of electrons in camera sensors and circuits. It can be introduced at any frequency at any time. IN is a short noise acting on a short interval of time. It can be introduced due to the synchronization error in transmission, ie error occurs in image signal while an image is being sent electronically from one place to another. In this each pixel of the image is corrupted by IN, in such a way that some portion of the pixels are randomly changed while others remain unchanged. In general IN are mainly of two types Salt and Pepper Impulse Noise (SPIN) and Random Valued Impulse Noise (RVIN). SPIN is occurring white and black pixels. This type of the noise produces sharp and sudden disturbances in the image. RVIN can have any value between 0 and 255, hence its removal is very difficult.

Many removing techniques are used to remove either AWGN or IN [1-4]. Impulse noise is effectively removing by using non linear filters. Non linear filters can preserve edges, and powerful than linear filters, because reducing noise levels without blurring edges. Non linear filters such as median filter [5] are used to remove random valued impulse noise. It is used to reduce the amount of intensity variation between one pixel and other pixel. One disadvantage of median filter is image local structure can be destroyed.

To achieve better image local structure weighted median filter [6], center weighted median filter are used, but it cannot determine the current pixel is noise or not. Another way is to detect IN pixels only and leave the uncorrupted pixels unchanged. AWGN is the important noise model in the image processing. Linear filters such as Gaussian filtering can be used to remove AWGN, it can smooth noise efficiently but they will destroy the fine details of image such as edges, texture etc. To solve this problem non linear filter such as Bilateral filter [7] is developed. Bilateral filters can preserve edges.

Mixed noise removal is very difficult task for image processing. Mixed noise is the combination of IN and AWGN. The median based signal dependent rank ordered means (SDROM) (8) filter can be used for mixed noise removal. It is very important to suppress of mixed noise in an image, and visually unpleasant artifact can be produce by SDROM filter. Switching bilateral filter (SBF) is another filter used for noise removal. Based on the method of detection and replacement SBF is used. We cannot find whether a current pixel is noise or not in SBF. Fuzzy Impulse Noise Detection and Reduction Method (FIRDM) (9) filter is the other method for mixed noise removal. IN detection step and noise reduction step are the two steps of FIRDM filter. It can preserve edge sharpness. SPIN can be effectively removed by FIRDM filter, but it is not satisfactory removing RVIN, because RVIN may not produce large gradient value.

Many mixed noise removal methods are based on the method of detection and replacement. First is the IN pixels detection and second step is eliminate noise. AWGN and IN is strong such a two phase task will become less effective. The trilateral filter (TF) is the combination of rank order absolute difference (ROAD) and BF. The main advantage that does not need separate IN pixel detection step, and also a simple model. It can effectively remove mixed AWGN and RVIN, but its performance in removing mixed AWGN and SPIN is not satisfactory. In this paper, wavelet transform along with dictionary method is proposed. The proposed method can

BINCY BABY, Electronics and communication Department, Kerala University, Younus College Of Enginerring and Technology, Kollam , India
SOUMYA D S, Electronics and communication, Kerala University, Younus College Of Enginerring and Technology , Kollam, India.

effectively remove the mixed noise while preserving the image information well.

II. WAVELET TRANSFORM WITH DICTIONARY METHODS

A. Mixed Noise

Consider the image model, *p* is denoted an image and by and by $p_{i,j}$ its pixel at location (i, j). Let *q* be the noisy observation of p. For additive white Gaussian noise (AWGN), each noisy pixel $p_{i,j}$ in q is modeled as $q_{i,j} = p_{i,j}+u_{i,j}$, where $u_{i,j}$ is i.i.d. noise and follows zero mean Gaussian distribution. The most commonly used IN are Salt-and-Pepper Impulse noise (SPIN) and Random-Valued Impulse noise (RVIN). Denote by [d_{min}, d_{max}] the dynamic range of q. The SPIN noise model can be described as follows: $q_{i,j} = d_{min}$ with probability $x/2$, $q_{i,j} = d_{max}$ with probability $x/2$, and $q_{i,j} = p_{i,j}$ with probability 1-*x*, where $0 \le x \le 1$. The RVIN noise model can be defined as: $q_{i,j} = d_{i,j}$ with probability *y* , and $q_{i,j} = p_{i,j}$ with probability 1-y, where $0 \le y \le 1$ and $d_{i,j}$ is uniformly distributed within [d_{min}, d_{max}] .

The signal observation model for the mixed noise types are described as follows

(a) AWGN mixed with SPIN

$$q_{i,j} = \begin{cases} d_{min}, & \text{with probability } x/2 \\ d_{max}, & \text{with probability } x/2 \\ p_{i,j}+u_{i,j}, & \text{with probability } 1-x \end{cases}$$

(a) AWGN mixed with SPIN and RVIN

$$q_{i,j} = \begin{cases} d_{min}, & \text{with probability } x/2 \\ d_{max}, & \text{with probability } x/2 \\ d_{i,j} & \text{with probability } y(1-x) \\ p_{i,j}+u_{i,j}, & \text{with probability } (1-y)(1-x) \end{cases}$$

III DENOISING MODEL

The denoising process is done with two filters. The filtering Process is done in two steps. . In the first technique KSVD algorithm and discrete wavelet transform followed by a thresholding method is utilized. In the post filtering technique the error between the noisy image and precoded image is calculated and the error is minimized. So that a clear image can be obtained as the output. The proposed method does not perform impulse pixel detection and AWGN removal separately but conducts the two tasks in a unified framework.

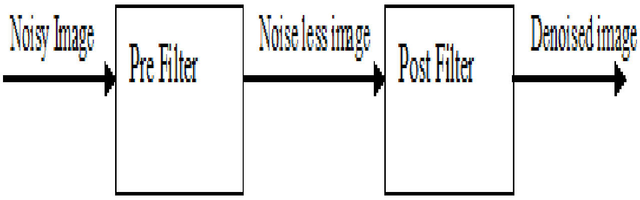


Fig.1.Block Diagram of mixed noise removal

A. Pre filtering

Using a dictionary and coding vector any image can be coded. Before applying the noisy image to a filter, the noise content is reduced. This process involves a prefiltering step, forward wavelet transform, KSVD algorithm, thresholding and inverse wavelet transform. The ability to capture the energy of a signal from few energy transform value is effectively implemented using wavelet transform technique. Let *m* be the observed image, and m , *p* € R1 X R2 be the size of noisy and clean image respectively. Every small image can be sparsely represented as the linear combination of a pre-learned dictionary. Threshold can be calculated using soft thresholding technique. After applying inverse wavelet transform, the coefficient for noise less image is obtained. This image has high PSNR value and so the clear image is obtained after the prefiltering.

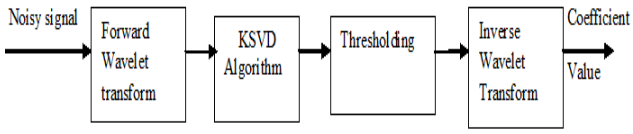


Fig.2. Block Diagram of Prefiltering Technique

B. KSVD ALGORITHM

- Pixels are selected from the input
- Unused pixels are replaced with minimally represented signal
- Signals which uses *k*'th pixels are identified
- *k'* th pixels is deselected from the dictionary
- Error coding matrix is calculated for the signals
- The error matrix is minimized with rank-1 approximate from SVD

C. Post filtering

With the help of a coding vector and pre-learned dictionary the image can be coded as

$$P=\Phi\beta \tag{1}$$

Where β is the set of all coding vector βi . The encoding model for AWGN is

$$\hat{\beta} = \arg\min_{\beta} \|q-\Phi\beta\|_2^2 \tag{2}$$

The data fidelity term $\|q-\Phi\beta\|_2^2$ in Eq. (2) lead to a MAP solution for AWGN removal. The data fidelity term can be changed by including an appropriate weight term for the mixed noise removal.

$$\hat{\beta}=\arg\min_{\beta}\|W^{1/2}(q-\Phi\beta)\|_2^2 \tag{3}$$

where W is a diagonal matrix having elements $W_{ii}=W_i$

$$W_{ii}=\exp(-ae_i^2) \tag{4}$$

The Difference between noisy pixel and error pixel can be calculated as $e = q-\Phi\beta$ (5)

The block diagram of post filter is shown below.

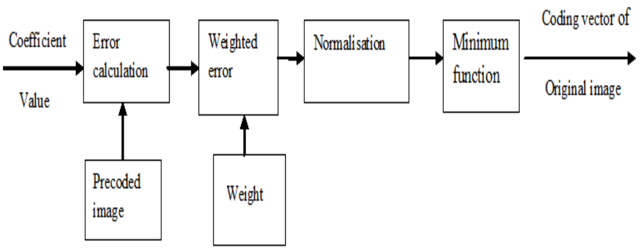


Fig.3. Block Diagram of Post Filter

D. The Dictionary

Five high quality images (fig.4) are used for training the dictionary. 876,359 patched are extracted from the images and are clustered together to form 200 clusters using K-means clustering algorithm. A local dictionary is learned for each cluster and centroid is calculated. The dictionary associated with the closest cluster is selected and the given patch is encoded using dictionary.

Fig.4.Five high-quality image

E. Algorithm of Weighted Encoding Dictionary Method

- Input: Dictionary Φ, noisy image q;

  Initialize W,

  Initialize e

- Output: Denoised image P
- Loop: iterate on *K*=1,2……k;

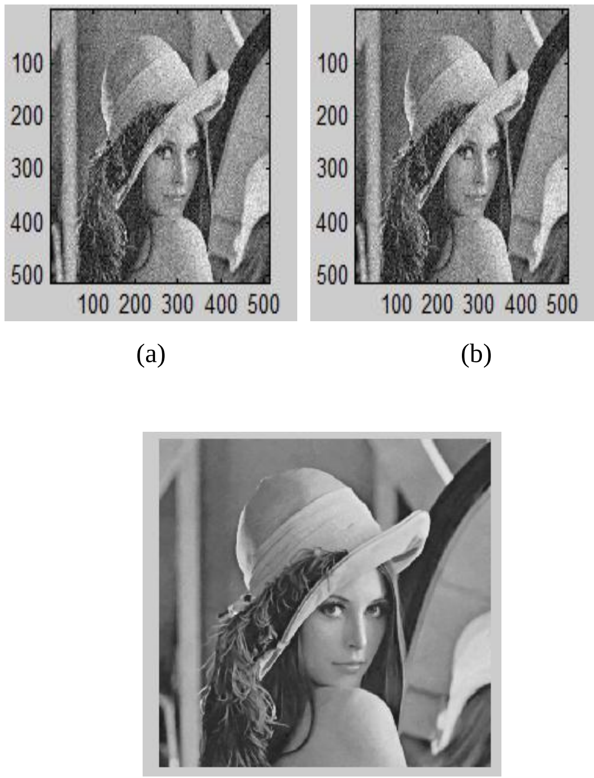
1 Compute $\beta^{(k)}$ by Eq. (2)

2 Compute $p^{(k)} = \Phi\beta^{(k)}$

3 Calculate the weights W by $e^{(k)}$ using Eq.(4)

IV. EXPERIMENTAL RESULT

The proposed method reconstructs clear image with less artifacts and also the image edges are sharper. Thus a clean, visually pleasant denoised image can be obtained as output. Fig. 5(a) shows the original image and Fig.5 (b) shows the Lena images corrupted by mixed noise. Wavelet Transform with Dictionary method produces an image with better quality compared to the existing methods. Experimental result shows image with high PSNR value for different standard deviations. For a given variance σ = 10, the PSNR value for noisy image is 10.6 and the PSNR value for the denoised image at for using the proposed method is 33.6. This method reconstructs the original image while preserving the image information well.



(a) (b)

(c)

Fig.5. Denoising result of Lena image. (a) Original image. (b) Image corrupted by mixed noise. (c) Denoising image

V. CONCLUSION

Wavelet transform along with dictionary method effectively mitigates the effect of mixed noise in images. The image corrupted by mixed noise shows an irregular distribution which is not so easy to remove. Wavelet techniques are very effective and have high PSNR values. Weighted encoding technique reduces the noise to the minimum level. Wavelet transform with dictionary method has to remove AWGN and IN jointly. The distribution of mixed noise is more irregular than gaussian noise. In this paper along with wavelet transforms ,weighted encoding dictionary , image sparsity and are integrated into a single unified framework, which is called regularization process to improve the stability and efficiency of weighted encoding model over the noisy image. The results clearly show that output performance is better than other existing methods.

ACKNOWLEDGEMENT

The authors would like to thank anonymous reviewers for their constructive comments and valuable suggestions that helped in the improvement of this paper.

REFERENCES

[1] M. Aharon, M. Elad, and A. Bruckstein, “K-SVD: An algorithm for designing of overcomplete dictionaries for sparse representation,” IEEE Trans. Signal Process., vol. 54, no. 11, pp. 4311–4322, Nov. 2006G.

[2] K. Dabov, A. Foi, V. Katkovnik, and K. Egiazarian, “Image denoising by sparse 3D transform-domain collaborative filtering,” IEEE Trans. Image Process., vol. 16, no. 8, pp. 2080–2095, Aug. 2007.

[3] L. Zhang, W. Dong, D. Zhang, and G. Shi, "Two-stage image denoising by principal component analysis with local pixel grouping," Pattern Recognit., vol. 43, no. 4, pp. 1531–1549, Apr. 2010.

[4] W. Dong, L. Zhang, G. Shi, and X. Li, "Nonlocally centralized sparse representation for image restoration," IEEE Trans. Image Process., vol. 22, no. 4, pp. 1620–1630, Apr. 2013.

[5] Pitas and A. N. Venetsanopoulos, Nonlinear Digital Filters: Principles and Applications. Norwell, MA, USA: Kluwer, 1990. .

[6] Y.Dong and S.Xu, "A new directional weighted median filter for removal of random-valued impulse noise," IEEE Signal Process. Lett., vol. 14, no. 3, pp. 193–196, Mar. 2007.

[7] C. Tomasi and R. Manduchi, "Bilateral filtering for gray and color images," in Proc. IEEE 6th Int. Conf. Comput. Vis., Jan. 1998, pp. 839–846

[8] 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 Process., vol. 5, no. 6, pp. 1012–1025, Jun. 1996

[9] S. Schulte, M. Nachtegael, V. De Witte, D. Van der Weken, and E. E. Kerre, "A fuzzy impulse noise detection and reduction method," IEEE Trans. Image Process., vol. 15, no. 5, pp. 1153–1162, May 2006

BINCY BABY received bachelor degree B. Tech in ECE from Baselious second college of engineering Kollam. Currently doing M. Tech student in AE&I, YCET Kollam, Kerala.

SOUMYA D S received the bachelor degree B.Tech in ECE from university of engineering karyavattom. Also she received her master's degree M.Tech in ECE from Narayana guru College of Eng. Mangalumude. Currently she is working as Asso. Professor in Dept. of ECE at Younus College of Engineering and Technology, Kollam, Kerala