Signal Processing and Renewable Energy
March 2017, (pp.37-45)
ISSN: 2008-9864

A New Adaptive Method for Removing Impulse Noise from Medical Images

Milad Mirzabagheri*
Electrical Engineering Department, Islamic Azad university, South Tehran Branch, Tehran, Iran

Abstract
This paper presents an efficient adaptive filter, to remove impulse noise from X-ray images. This filter has two stages. At the first stage, based on the intensity value, the pixels are classified into two classes, which are noisy pixels and noise- free pixels, the noisy pixels are only processed and the noise-free pixels remain unchanged. In this method the size of window is adaptively changed and the edges and details are preserves, hence for the replacing noisy pixels, two issues are considered the noise-free pixels and the level of noise in an image. The result from 50 test X-ray images showed that this method is promising to remove the impulse noise from X-ray images.

Keywords: Impulse noise, X-ray images, adaptive filter, edges

1. INTRODUCTION

Medical imaging plays a pivotal role in radiological sciences to present structures of the human body. From imaging we get valuable information to evaluate the treatment of organs. Medical imaging is a crucial diagnostic tool to analyze different parts of the body such as bones and soft tissue. One of the medical imagings is the X-ray imaging .The X-rays were discovered in 1895and because of their penetrating ability were used for imaging the human body [1]. Errors in sensors or A/D converter may cause impulsive noises in radiographies. The impulsive noise poses problem not only in edge detection and feature recognition but also in hospital and clinical practice which leads to studying images subjectively by human [2]. Many techniques have been introduced to separate information from noisy signals and these techniques adapted to two dimensions for images. Linear methods have a lower cost of computation while using them smooths out the edges [3].The median filter is a nonlinear filter and is superior to linear filter. To calculate The median filter for an image we move window over an image and the output is the median of the window [4],[5],[6].The power to remove noise and computational efficiency make the median filter ideal to remove the impulse noise, but when the noise level is over 50%, some details and edges will be lost [7].The typical median filter for images changes both corrupted pixels and uncorrupted pixels. Accordingly, the image will be blurred [8]. The adaptive median filter is a kind of median filter which has shown better results. Unlike the median this one has a classification part which primarily classifies the pixels in to two groups: 1. corrupted pixels 2. uncorrupted pixels and just filter out the corrupted pixels. In adaptive median filter size of the window can increases at the presence of higher level noises. In fact, the window size depends on the level of noise in an image. This filter is superior to the

*Corresponding Author's Email: Miladi86@yahoo.com

median filter. However, suffers from poor results, when the level of the noise is high [9]. Different filter techniques have been proposed to remove the impulsive noise. Namely, the generalized trimmed mean filter [10], the generalized morphological filter [11], the homomorphic and adaptive order statistics filter [12], these filters have poor results at the presence of the high level of noise. In recent years some methods have been proposed: the wavelet filters [13,14] the fuzzy algorithms [15,16], and the neural networks technique [17]. These methods have better results with respect to the median filter, while they suffer from the costs of computation, the training database, and the long processing time. In another research, a method has been introduced which is based on adaptive median filter and performs a better result comparing with the adaptive median filter. In this method the window increases until it finds at least one noise free pixel in the window and in this window the noisy pixel is replaced by the pixel which is the nearest to the adaptive median [18]. In this paper, a new Impulsive noise removal method based on median filter is proposed to restore X-Ray images corrupted by fixed-valued impulse noise. First, the pixels are classified into two classes: 1. Noisy pixels 2. Noise free pixels and then only noisy pixels will be processed and the noise free pixels remain unchanged. The window size in this work is adaptive and will increase in high level noises by the threshold which depends on the size of the window and noise free pixels in window, the adaptation which is automatic. There is one parameter should be given manually and this parameter depends on the noise level, which is given in section 2.

This paper is organized as follows. In section 2 we explain the proposed method in details. In section 3 we provide our experimental result subjectively and objectively and the discussions. Finally, the conclusion of our study is provided.

2. THE PROPOSED METHOD

Let $I(x,y)$, $V(x,y)$, and $U(x,y)$ denote original , corrupted, and noise-removed images respectively, where x and y are their spatial indexes, and X and Y are their sizes.

$$I_{x,y} = I(x,y)$$
$$V_{x,y} = V(x,y) \tag{1}$$
$$1 \le x < X, 1 \le y \le Y$$

For distinguishing, the corrupted image may be modeled as mentioned below:

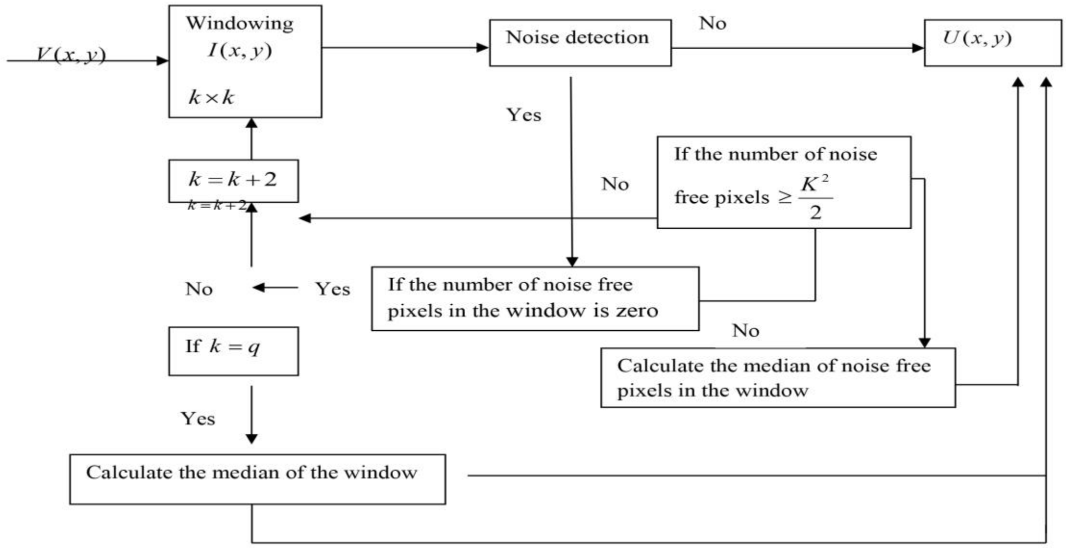
$$\begin{cases} H_0 : V_{x,y} = \left| I_{x,y} \right| \\ H_1 : V_{x,y} = \left| n_{x,y} + I_{x,y} \right| \end{cases} \tag{2}$$

Where H_0 and H_1 represent original and corrupted pixels respectively.

The proposed method provides the ability to preserve the edge after noise-removing process. Noise detection is a vital process to provide better medicine assessments in the X-Ray images. The proposed algorithm has two stages: 1) noise detection 2) filtering. The filtering part uses two conditions: 1) the relation between the number of noise free pixels and the size of the window.2) during facing a noisy window, the relation between the parameter q and size of the window will be considered. Where the parameter of q has been used to distinguish the tissue and background of the x-ray images from the noisy pixels. Because the noisy pixels and the tissues and the back ground take either 0 or 255 in the x-ray images.

The value of q should be given manually and its value depends on the level of the noise in the image. According to our experimental result the suitable value for q at the noise level of 0% to 30% could be 3 or 5 and at the noise level of 30% to 60% could be 3, 5 or 7.

The below diagram represents our method:



The filtering process applied on the whole image by shifting window as $\Omega_{x,y}^{k}$ which has the size of k centered at (x,y):

$$\Omega_{x,y}^{k} = \{(m,n) : |m-x| \leq k, and, |y-n| \leq k\} \quad (3)$$

Let $A(x,y)$ be the detection ratio which is modeled as you see below:

$$A(x,y) = \begin{cases} 1 : V(x,y) = 255 \\ 1 : V(x,y) = 0 \\ 0 : else \end{cases} \quad (4)$$

$$\eta = k^2 - M_{Max} - M_{Min} \quad (5)$$

Where η is the number of noise free pixels in the window of $\Omega_{x,y}^{k}$, and M_{Max} and M_{Min} are the numbers of those pixels with the value of 0 and 255 respectively.

$$\eta \geq \frac{k^2}{2} \quad (6)$$

(6) Represents the second condition of the noise cancelation process.

$$G(x,y) = Med\{\Omega_{x,y}^{k}\} \quad (7)$$

(7) Represents the median of the window of $\Omega_{x,y}^{k}$.

We model our method as a bellow:

$$U(x,y) = [1 - A(x,y)]V(x,y) + A(x,y)G(x,y)] \quad (8)$$

Where $G(x,y)$ is the value that we calculate in the noise cancelation process and also $U(x,y)$ can be simplified in the below equation:

$$U(x,y) = \begin{cases} I(x,y) : A(x,y) = 0 \\ G(x,y) : A(x,y) = 1 \end{cases} \quad (9)$$

It should be noted that, when two conditions of the noise cancelation process are not satisfied, the window will be increased to the next odd number.

3. EXPERIMENTAL RESULT

In this section, the visual image quality and quantitative measures are used to evaluate our method. In order to show the performance of our method, we also implemented the other methods: the method proposed by Jain [6], by Hwang and Hadad [9] , and, by singh and mehrotra [18] .

In this work, we use 50 X-Ray images from different parts of the human body. Samples of these images are shown in Fig.2 (a), Fig.3 (a), and Fig.4 (a). To examine the performance of methods we contaminate the images with fixed-valued impulsive noise (i.e. “salt& pepper" noise) and in our examination we increase the noise level from the density of 5% to 60%. The results are presented in terms of subjectivity and objectivity (root mean square error (RMSE) and peak signal noise ratio (PSNR)).

$$MSE = \frac{1}{XY}\sum_{Y-1}^{X-1}\sum_{y=0}^{Y-1}[U(x,y)-I(x,y)]^2 \tag{10}$$

$$RMSE = \sqrt{\frac{1}{XY}\sum_{x=0}^{X-1}\sum_{y=0}^{Y-1}[U(x,y)-I(x,y)]^2} \tag{11}$$

$$PSNR = 10\log(\frac{255^2}{MSE}) = 20\log(\frac{255}{RMSE}) \tag{12}$$

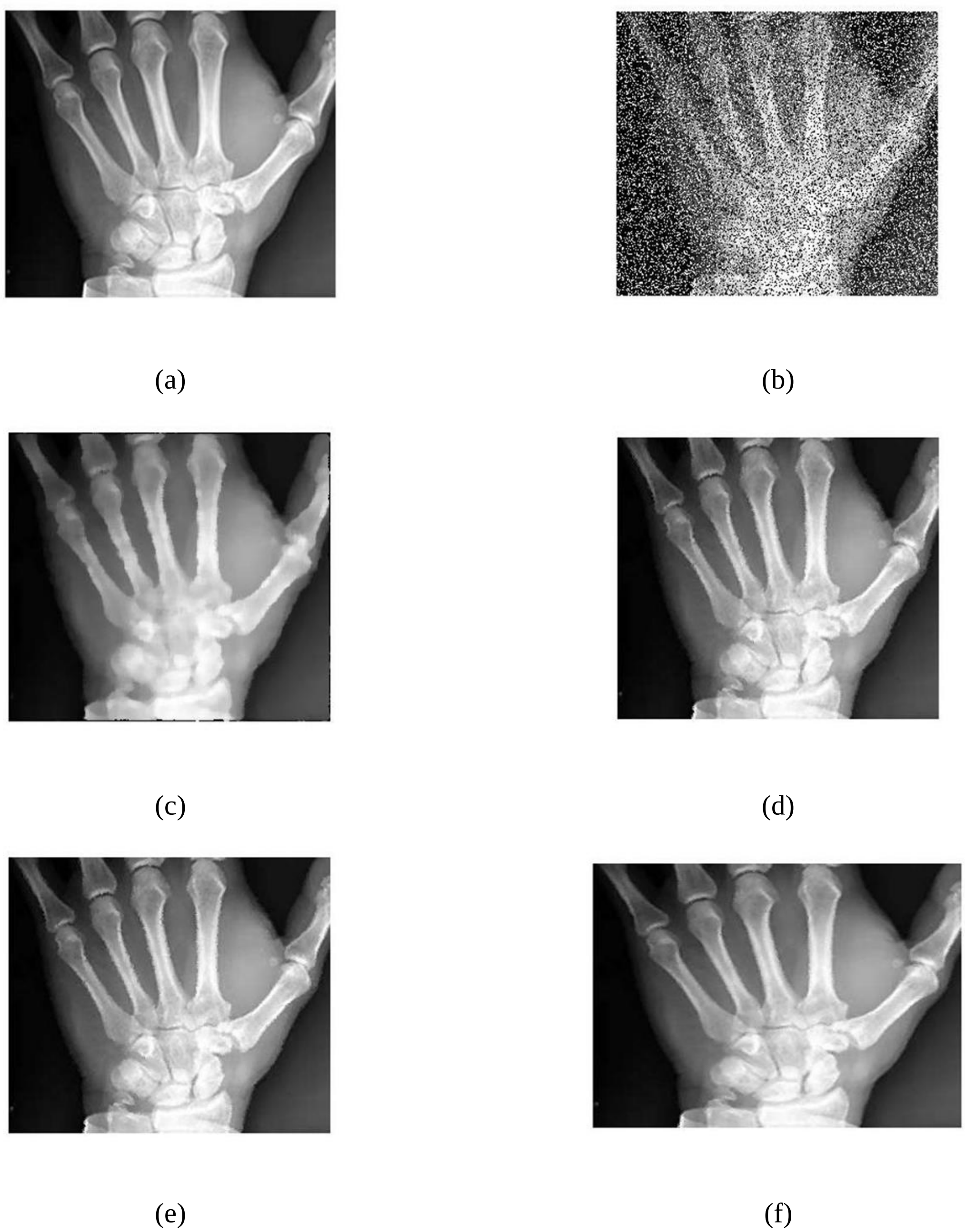
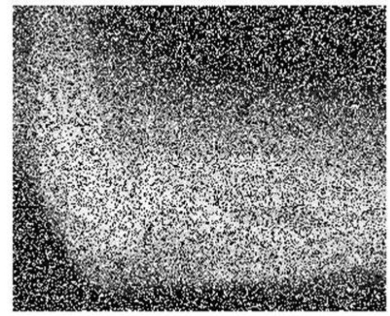
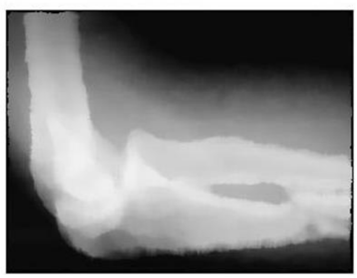


Figure.2."X-ray Image of a hand" (a) The original image. (b) The image corrupted by 40% noise. (c) The image from method [6].(d)The image from method [9].(e) The image from method [18].(f) The image from our method .

(a)



(b)



(c)

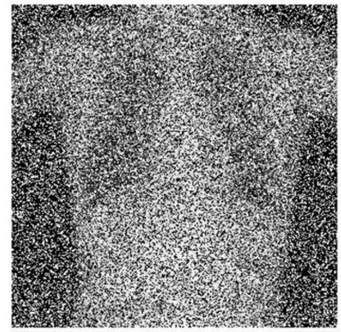
(d)

(e)

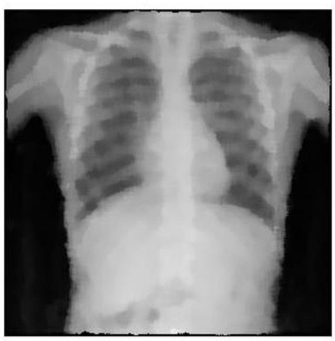
(f)

Figure.3"The X-ray Image of an elbow" (a) The original image. (b) The image corrupted by 50% noise. (c) The image from method [6].(d) The image from method [9].(e)The image from method [18].(f) The image from our method .

(a)



(b)



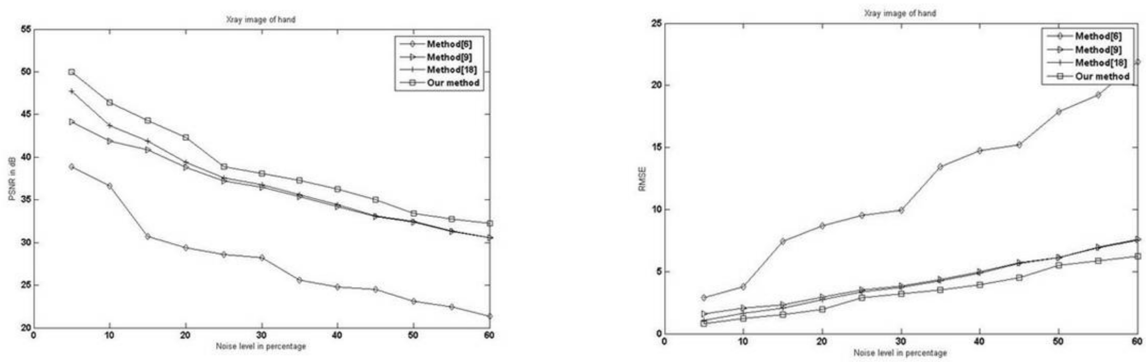
(c)

(d)

(e)

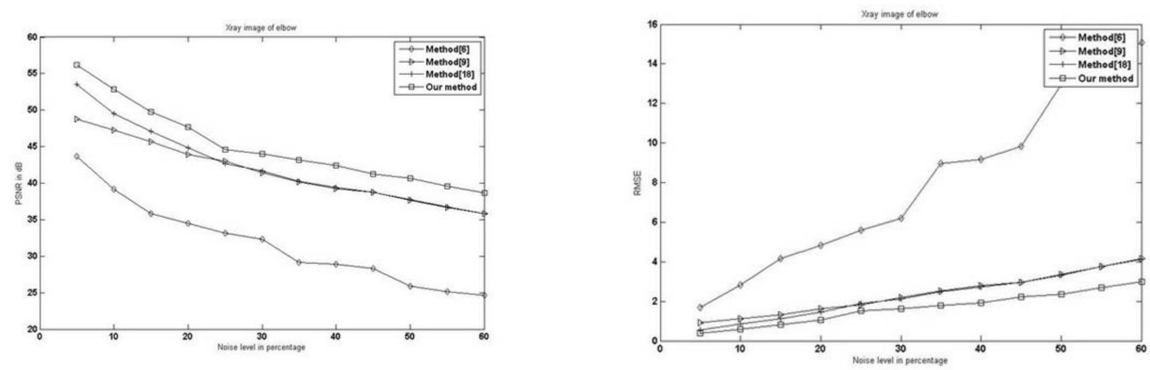
(f)

Figure .4.''X-ray Image of chest" (a) original image. (b) Image corrupted by 60% noise. (c) Image from method [6].(d) Image from method [9].(e) Image from method [18].(f) Image from our method .



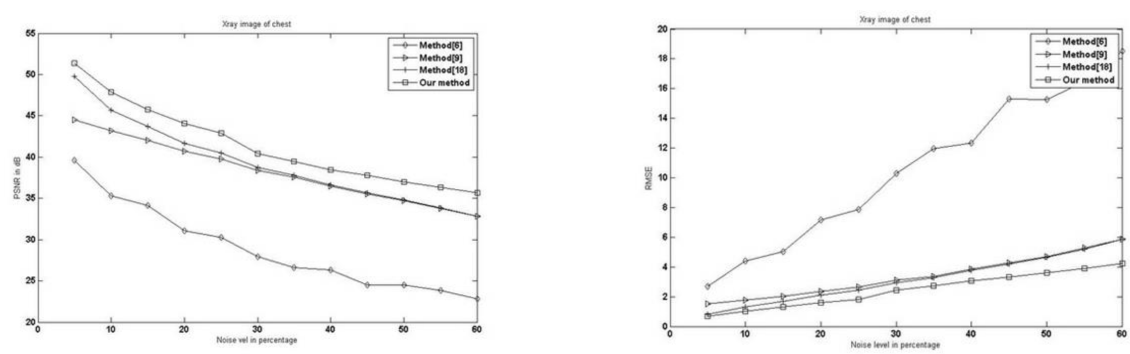
(a) (b)

Figure .5.Objective result of X-ray image of hand.(a)shows the PSNR_Noise.(b)shows the RMSE_Noise.



(a) (b)

Figure. 6.The objective result of X-ray image of elbowt.(a)shows the PSNR_Noise.(b)shows the RMSE_Noise.



(a) (b)

Figure.7.The objective result of X-ray image of chest.(a)shows the PSNR_Noise.(b)shows the RMSE_Noise.

Fig.2 represents the results derived from different methods for the X-Ray image of hand that is corrupted by 40% of impulsive noise, which is a quit low noise level. Based on the images, all methods can preservedges successfully, although, method [6] smooths out a little the edges. We see that the method [9] and the method [18] degraded a little the edges, but our method could preserve the edges very well at this noise level.

We can also understand this objectively by seeing the Fig.5 and see that our method has the most PSNR and the least RMSE.

Fig.3 shows the result from different methods for the X-Ray image of elbow, which is contaminated by 50% of impulsive noise. This noise level is considerably high. The method [6] could not preserve the details and blurred the image. From the images, we see that there are distortions in the edges of images that are the output of the method [9] and the method [18]. Our method preserves the edge better than these methods and from the Fig.6 like Fig.6 our method has the most PSNR and the least RMSE.

Fig.4 shows that the method [6] smooths out the edges considerably and the details are lost. The method [9] and the method [18] failed to preserve edges and there are relatively high distortions in the edges of their images. However, our method could preserve edges better and there are less distortions in the image of our method. Form the Fig.7; we can see objectively our better results regarding other methods.

4. CONCLUSION

This paper presents a new method to remove impulse noise from low to high corrupted X-ray images. The technique has the advantages of not requiring to data-base and previous training. To preserve details and edges the window size is adaptable to the noise-free pixels and the noise level in an image. Experimental result shows that this filter can remove impulse noise efficiently and preserve details well.

REFERENCES

[1] Dhawan, A., Medical Imaging Modalities:

[2] XRay Imaging, Wiley-IEEE Press, 2011, pp.79-97

[3] Frosio,I. ,Borgheses,N.A.," Statistical Based Impulsive Noise Removal in Digital Radiography", IEEE Transactions on Medical Imaging, Volume .28,no.1,2009,pp.3-16

[4] Runtao, D, and Venetsanopoulos, A.N.,"Generalized homomorphic and adaptive order statistic filters for the removal of impulsive and signal-dependent noise", IEEE Transactions on Circuits and Systems, vol.CAS-34, no. 8, 1987, pp.948-955

[5] Astola, J. Haavisto, P., and Neuvo, Y.,

[6] "Vector median filters," Proceedings of the IEEE, Vol.78, 1990, pp. 678-689

[7] Bovik,A.C.,Haung,T.S,Munson,D.C.,Jr," A generalization of median filtering using linear combinations of order statistics", IEEE Transactions on Acoustics, Speech and Signal Processing, Volume.31,no.6,1983,pp.1342-1350

[8] A.K. Jian, Fundamentals of Digital Image Processing.Englewood Cliffs,NJ ,Prentice hall,1989

[9] Chan, R.H., Chung-Wa, H., and Nikolova, M., "Salt-and-pepper noise removal by median-type noise detectors and detail-preserving regularization," IEEE Transactions on Images Processing, vol. 14, no. 10, 2005, pp. 1479- 85

[10] Abreu,E.,Lightstone,M.,Mitra,S.K.,

[11] Arakawa,K," A new efficient approach for the removal of impulse noise from highly corrupted images", IEEE Transactions on Images Processing, vol. 5, no. 6,1996,pp. 1012-1025

[12] Hwang, H., and Haddad, A., "Adaptive median filters: New algorithms and results," IEEE Transactions on Images Processing, vol. 4, no. 4, 1995, pp. 499-502

[13] Rytsar ,Y.B., Ivasenko, I.B.,"Application of (alpha, beta)-trimmed mean filtering for removal of additive noise from images",SPIE Proceeding.Optoelectronic and Hybrid Optical/Digital Systems for Image Processing,1997,pp45-52.

[14] Chunhui, Z., Qingbin, X., Wei, N., "Study on the noise attenuation characteristics of generalized morphological filters",SPIE Proceeding Medical Imaging,1998,pp.236-9

[15] Runtao,D.,Venetsanopoulos,A.

[16] "Generalized homomorphic and adaptive order statistic filters for the removal of impulsive and signal dependent noise". IEEE Transaction on Circuits System, Volume.34,no.8,1987,pp.948-955.

[17] Karthikeyan,K.,Chandrasekar, C., "Speckle Noise Reduction of Medical Ultrasound Images using Bayesshrink

Wavelet Threshold", Int J Comput Appl,2011,Volume.22,pp.8-14.

[18] Wang,L.,Lu,J.,Li,Y.,Yahagi,T.,

[19] Okamoto,T.,"Noise reduction using wavelet with application to medical X-ray image",International Conference on Industrial Technology,volume.20,2005, pp.33-8.

[20] Russo,F.,Ramponi,G.,"A Fuzzy filter for images corrupted by impulse noise", IEEE Signal Processing Letters,volume.3 ,no.6,1996,pp.168-170.

[21] Anisha,K.,Wilscy,M."Impulse noise removal from medical images using fuzzy genetic algorithm",Int J Multimed Appl ,2011,3:93-106.

[22] Liang,SF, Lu, SM, Chang, JY,and Lin, CT., “A Novel two-stage impulse noise removal technique based on neural networks and fuzzy decision,” IEEE Transactionson Fuzzy Systems.,vol.16, 2008, pp. 16:863-73

[23] Singh,K.K.,Mehrotra,A.,

[24] Nigam,M.J.,Pal,K.,” A novel edge preserving filter for impulse noise removal”, International Conference on Signal Processing and Communication Technologies(IMPACT) Multimedia ,2011