A robust approach for medical image denoising using fuzzy clustering

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Abstract
Image segmentation plays an important role in medical imaging applications. In this paper, a new method for removing noise in medical images is provided. What is important is to be able algorithm implemented with minimum complexity of computational mathematics and minimum running time functionality is optimized and can reduce noise while the edges, not harm, and the noise are minimized. For this purpose, the normalized image and our image segmentation so that section to separate the important and less important. Using fuzzy clustering can greatly improve noise. The experimental results showed good performance in removing noise method with low computational complexity.

Keywords:
Medical images, Remove noise, Image segmentation, Fuzzy clustering

1. Introduction

One of the main focuses of interest in image processing, medical imaging. With the advancement of technology, along with increasing the size and resolution of the images, their size has also increased. In such a way that today three-dimensional or four-dimensional images are used. There are sections on medical images, which is very important in medical diagnosis. The department determined by a physician for any type of image, and the area of interest, the main area or region of interest or ROI said that-be. What is mentioned above, it becomes clear, that this area of the image is important and leads to wrong diagnosis by the doctor's decision. The area is not the doctor's diagnosis insignificant or unimportant area (Region of Non-Interest) call. And it is said RONI, in most of the articles that have been proposed so far in the field of medical images, a range of image as an area of importance identified and out of that range area is considered insignificant or unimportant.

However, our look is a little different to determine the areas and closer to the doctors. All medical terms medical image area is important and should not eat. One of the most important issues, which should be enough to reduce the noise in medical images. Common approach on noise reduction and restoration of the image using various filters, such as filters, morphology. The great thing about this type of site it is usually appropriate for certain types of noise and adapts them to remove noise is no longer possible. Non-linear filters such as median filter is effective in removing all types of noise. The median filter is able to separate the noise or noise apart to remove the line while the edges of the image will not change. One of the disadvantages of the median filter is when the image of a threshold of 60% Noise accept that the filter is unable pixel non-noisy pixels of noise detect small details in the image with noise apart and so because filter performance greatly reduced. In Continues to introduction of some important work in this field in the paper. Babu et al. [1] a fuzzy logic algorithms for noise reduction offered Speckle. The algorithm is based on vibration parameters of noisy images are taken. All structural images using this parameter is specified. This is a two-step algorithm. In the first image using fuzzy logic and parameters of vibration in certain areas, it is divided. In the second stage, to make a distinction between the edges and noise a proper weighted average filter is used and compared with X-ray imaging to diagnose diseases better use. A de-noise filter according to a new converter structure [2] was proposed, combining this technique with the frequency and location combined with de-noise algorithm, super-resolution is used. The main disadvantage of this algorithm, the images using sensors with different frequencies.

Suzuki et al. [3] a way to fit right in the face of new noise sources suggested that this approach is based on neural network. The neural network can be trained using appropriate filters to select model number. Neural network filter using the training images for noise isolation properties of particle images to be handled, but when the input image characteristics vary with video tutorials, neural network filter can remove noise. In many cases different types of images cannot be used for network training. So how to develop neural network filters to images as a serious problem remains.

Bahendwar et al. [4] to reduce the noise level discrete wavelet transform used in medical images. The results show that despite the use of discrete wavelet transform is the acceptable amount of PSNR and image quality is not dropped. A detector noise reduction filter based on fuzzy logic to correct and improve its performance in [5] provided, in their proposal, the parameters are trained using genetic algorithms. The simulation results show that this detector can be effectively used to improve the performance noise reduction filter. Other methods of noise reduction, the noise speckle using Wiener filter [6] as well as new methods such as adaptive windows [7] can be cited. By using thresholding

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wavelet coefficients such as hard and soft thresholding operation noise is played in paper [8] have been proposed.

Structure of the paper is organized as follows. Section 2 introduces the basic concepts discussed. Section 3 presents the proposed algorithm. Operations and results discussed in section 4 of simulations. Finally, in Section 5 is a conclusion.

2. The basic concepts

In all the noise reduction algorithm that is completely focused image recovery. These algorithms are designed so that only if the noise is limited, resolve it. The method presented in this study are such that in the event of changes in inconsequential and important areas of functioning algorithm, and the algorithm will not be able to recover the image. This feature was created using fuzzy clustering. In addition, the proposed method, the algorithm is able to use features Dicom format and put the information in the header of a different modality medical images support.

2.1 Clustering-based segmentation

Fuzzy clustering is one of the methods of segmentation. This approach is based on fuzzy sets theory presents a method for the expression of uncertainty. Unlike conventional assemblies, whose members serve careful characterization, fuzzy sets are to functions that meet the defined characteristics (for non-exact) are among the members of the set size. Fuzzy clustering methods, are two form soft segmentation and hard segmentation. The usual method for image segmenting is soft. Segmentation Software, uncertain boundaries in place and allows the object may have overlapping areas. Soft segmentation methods, especially in finding a local volume effects are used, because the pixels that contain more than one type of the whole, and therefore belong to more than one class context. For resolution in areas of significance and importance of fuzzy clustering is used.

2.2 Decision in the fuzzy environment

The basic idea is that each member of the fuzzy set theory has a membership grade and a fuzzy set is defined by a membership function, the membership function to each of the members a degree of membership of that amount between the interval [0,1] is allocated. The absolute concept of zero or one based on the presence or absence of a member, by this theory to a number between zero and one altered relative concept. The theory of fuzzy sets with fuzzy logic are used in various applications and programs. Among the variety of applications, because we face the design and engineering concepts are imprecise and lack of sufficient information about the process, techniques discussed further in these areas is considered.

2.3 Triangular fuzzy numbers

View fuzzy numbers with the usual numbers are different. The numbers are triple M = (l, m, u) which is $l \le m \le u$ show. The membership function is a triangular fuzzy number M = (l, m, u) shown in Formula 1. Figure 1 also shows a triangular fuzzy numbers [12].

$$\mu(x) = \begin{cases} 0 & ; \quad x < l, \\ \frac{x-l}{m-l} & ; \quad l \le x \le m, \\ \frac{u-x}{u-m} & ; \quad m \le x \le u, \\ 0 & ; \quad x > u. \end{cases} \tag{1}$$

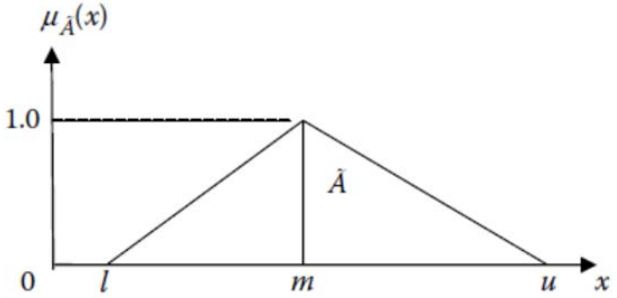


Figure.1 Triangular fuzzy numbers

To make mathematical operations such as multiplication, addition and division performed on triangular fuzzy numbers, the concept of A Cut (Cut-α) is used, the amount of numerical A between the interval [0,1] is. To obtain α cutting a triangular fuzzy number of formula 2 used.

$$\forall \alpha \in [0,1] M_{\alpha} = [l^{\alpha}, u^{\alpha}] = [(m-l)\alpha + 1, -(u-m)\alpha + u] \tag{2}$$

The result α cutting a triangular fuzzy number, a window will be closed. To perform arithmetic operations between two fuzzy numbers of the range is used.

3. The proposed algorithm

The algorithm that is in question, has the potential to reduce image noise and noise in all important areas of medicine. This algorithm has the potential to occur if the image noise, able to meet its full importance of this area will be in the area. It also supports different modalities of medical images. In the proposed algorithm first dividing image to an important area and several less important area. This is done by using fuzzy clustering soft border areas are separated. The number of minor areas on the periphery of images. It should be noted that the region has an area that is medically important diagnostic significance. After the clustering, an area important to the block and each block area is important for a number of blocks. After performing these calculations

all the blocks-regional importance with lossless compression JPEG compression, and compressed block size is calculated. Because Dicom original format, the compression is significantly reduced size. The size of each compressed block, should be placed in the least significant bits of the low value of the first areas and the compressed data blocks spikes, area important to the least significant bits are placed second, less important areas. The proposed clustering algorithm in Figure 2 is shown.

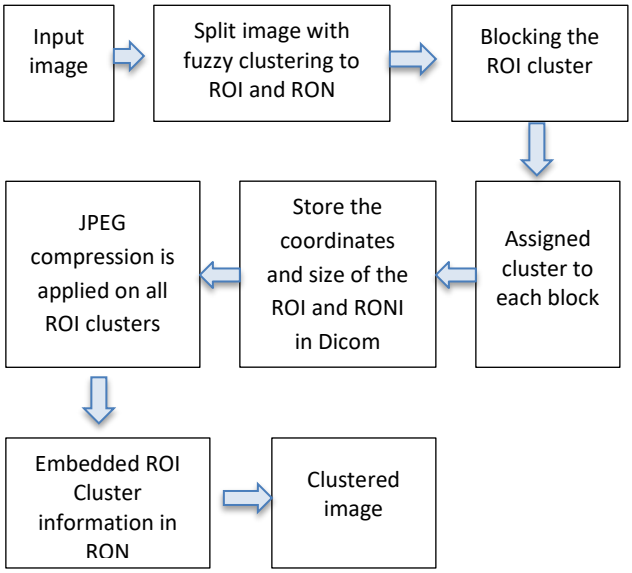


Figure.2 Clustering steps of proposed algorithm

At the destination, at first dimensions and the coordinates of less important cluster and important cluster areas of the image to be read and decoded. Then the area has been animportant block, and each block is assigned a number. If noise in the area of importance happened, to eliminate the noise, that noise is present in each block, that block is stored numbers and it block consider as noise block. Then using the profile of the respective clusters that have been put in Dicom, we retrieve the cluster information. All the information on the fuzzy filter and noise acts on this information, we hereby resolve. That is, using the coordinates of the area less important and block number modified in the cluster area of importance, where blocks are stored to find it, and then the compressed file to derive and on the filter we apply fuzzy. This correction bits that have been changed will be affected by noise. The information we decompress. In the modified blocks of pixels with pixel blocks extracted in block modified compared the effects of noise, and the pixel that has changed with the value stored in the file of our alternatives. The noise removal in the proposed algorithm is shown in Figure 3.

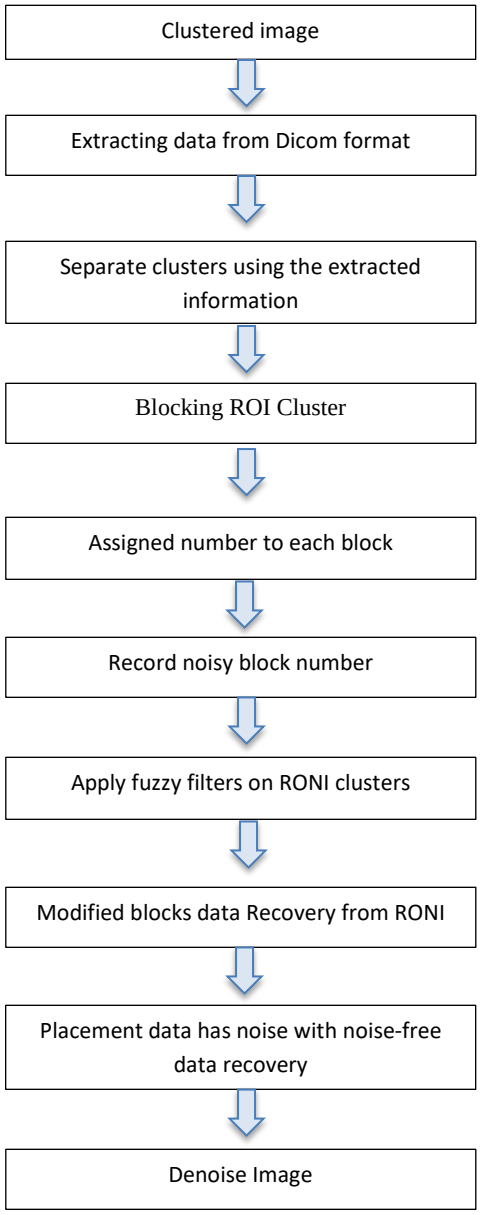


Figure.3 Process of noise removal in proposed algorithm

3.1 Preparation image at the origin

In each picture, the whole area of medical image as a region important to consider. To determine the size of minor areas, we need to do fuzzy clustering. 5 examples of medical images, including images, MRI, X-ray and Ultrasound used in this paper is shown in Figure 4.

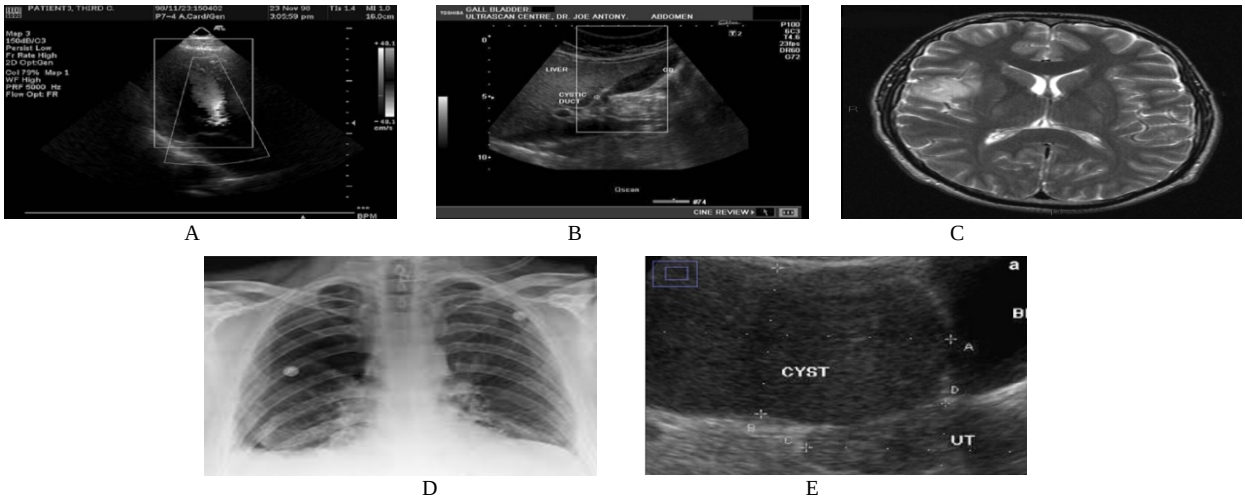
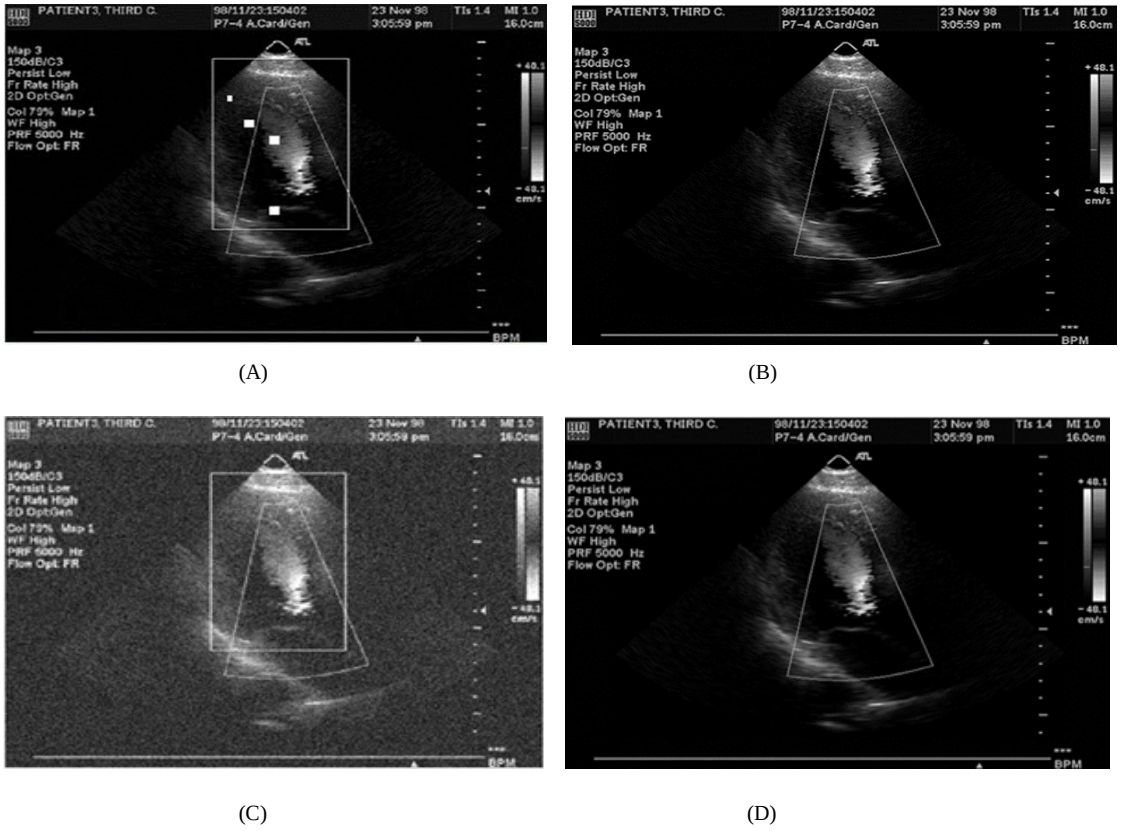


Figure.4 Five medical image used in the proposed algorithm (A) the first image (B) the second image (C) The third image (D) The fourth image (E) Fifth image

4. The results of proposed algorithm

Imposed noise in the image, including the image noise known as random noise, noise Gaussian, Poisson, salt & Pepper is and Speckle. The proposed algorithm is capable of any kind of noise in the picture as an acceptable ROI and resolve completely. Result of the noise and fix it by the proposed algorithm on the first sample image shown in Figure 5.



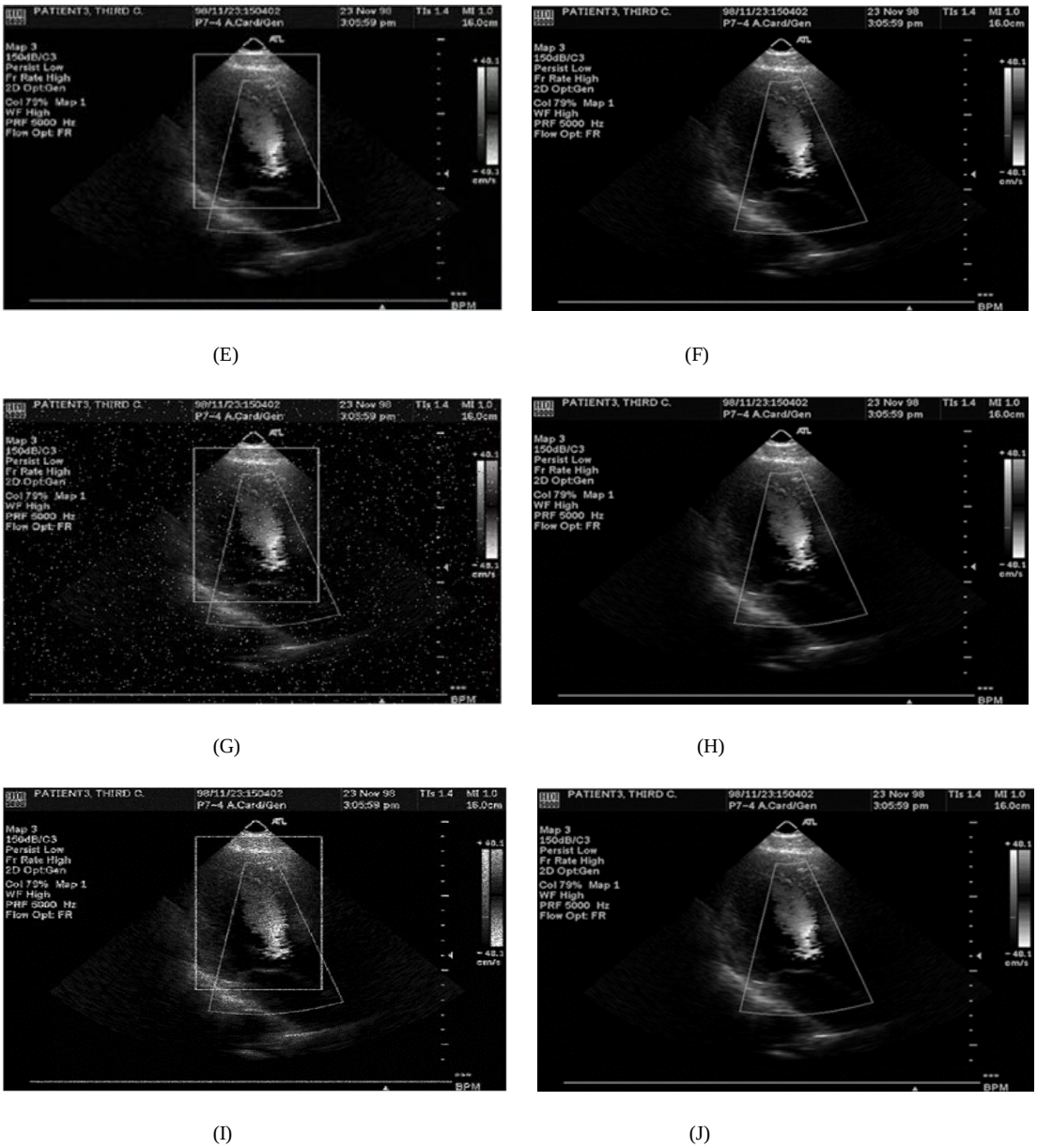


Figure.5 The result of applying noise and Noise removal by proposed algorithm on the first image. The sample of left column images, applied to various noises, including (A) random noise (C) noise Gaussian (E) noise Poisson (G) Noise salt & pepper (I) noise speckle - right column images is noise removal of images

Results are shown in Table 1. The preparation algorithm. After determining the size of the area negligible and the total number of pixels, with regard to store 2 bits of data per pixel (bits first and second low-value), the total volume that can be found in the information stored, designated Is. The numbers corresponding to the total number of bits in the region has been identified importance to the compression algorithm. Due to the number of bits obtained from the compression volume to store our information, it is known that all this information cannot be stored in the available space. So the number of blocks that can be stored in the ROI as far as space is available to store compressed and we put minor areas in clusters.

Table.1 Results of the preparation stages

	volume resulting from compression ROI clusters in bits	The total volume of storage clusters, including 2 bits per pixel	The total area of pixel based RONI	ROI percent in the image	ROI dimensions	Image Dimensions
First picture	395012	269400	134700	20.4	170*370	480 *640
Second image	518784	324200	162100	31.3	420*200	518*518
Third image	628488	285050	142525	37.8	350*290	518*518
Fourth image	495475	326500	163250	29.5	330*240	518*518
Fifth image	353707	322900	161450	35.6	330*290	518*518

Table 2 shows the result of the implementation of proposed algorithm on five picture show.

Table.2 The results of the implementation of proposed algorithm

	Percentage elimination of noise in the whole picture	Volume resulting from of clustering	The number of bits compression phase of the proposed method	The total number of bits of the cluster ROI proposed method
First picture	%98.4	241152	211008	244530
Second image	%97.3	316212	276685	320308
Third image	%97.8	277402	237773	281386
Fourth image	%98.4	300288	240231	304272
Fifth image	%98.8	292608	234087	296592

Benchmark intended to measure image quality by removing noise PSNR (peak signal to noise ratio) is. PSNR value is calculated using equation (3).

$$\mathrm{PSNR} = 10 \log \frac{(255)^2}{\mathrm{MSE}} \quad (3)$$

MSE (Mean Square Error) square error between the original image and the image is noisy and the Equation 4 is calculated.

$$\mathrm{MSE} = \frac{1}{\mathrm{MN}} \sum_{i=1}^{M} \sum_{j=1}^{N} (f_1(i,j) - f_2(i,j))^2 \quad (4)$$

That f_1(i, j) and f_2(i, j) to the original image without noise and the image is retrieved from the noise, M and N size image. In Table 3, the image quality and noise removal algorithm execution time for each image is specified.

Table 3 - image quality and noise removal algorithm execution time

	PSNR	Average running time in seconds
First picture	50	30.5
Second image	47.5	35.1
Third image	48	33.5
Fourth image	48.6	33.2
Fifth image	51.4	33.7

4.1 Reviews the main indicators and methods of denoising in medical images

According to Tables 1, 2, 3 and results of the algorithm on different samples, the main indicators and methods of noise in medical images pay.

- Image quality by removing noise: noise image quality fixes in an acceptable range between db 47.5 db 50 is up.
- Volume area noise: noise reduction in the rate of success in the important area of one hundred percent of the entire image is between 97 to 99 percent.
- Computational complexity: the computational complexity of the proposed procedure is acceptable in that it shows the computation time.

5. Conclusion

This paper presented a new algorithm to remove noise in medical images with low computational complexity and at runtime. For this purpose, first normalized image and then segmented the image so that separate the important section and less important. Using fuzzy clustering can greatly improve noise. The proposed method unlike other methods for the specific modalities of medical images will not be included. This noise unlike other methods not related to a

specific noise and types of noise are included. And improves the noise of the image is sent.

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