De-noising of Ultrasound Images with improved PNLM Algorithm

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Abstract - The image processing is the technique which processes the information which store in form of pixels. The ultrasound image are the medical images which have speckle noise. Due to presence of noise in the image, the image quality is reduced . The NLM is the filtering technique to denoise ultrasound image. The PNLM is the improved version of NLM for denoising medical images. In this research work, PCA algorithm is applied which define the window size dynamically. The proposed algorithm is implemented in MATLAB and it has been analyzed that proposed technique performs well in terms of PSNR, MSSIM and MSE.

Index Terms - PCA, PNLM ,NLM, MSE, PSNR, MSSIM

I. INTRODUCTION

In the field of image processing, image de-noising has become a necessary issue to be considered. In image processing frameworks the process of decreasing noise process is very important part. Denoising is a technique to removes the noise which have been included in the image before processing. While the process of capturing, processing and storing the quality of image get defective. For researcher expelling noise from the first images is become a hot topic to research as the noise will causes obscuring in the images.

1.1 Ultrasound imaging

In the field of medical system, ultrasound imaging is one of the most widely used because of the number of advantages of ultrasound imaging. In comparison to ultrasound imaging the x-ray and magnetic resonance imaging is inexpensive and it has low risk of image modality which provides real-time information. In today very fast development of medical imaging systems the ultrasound scanners have no exception. The additional method of ultrasound and its scanner have become very practical during the last two decades. The development is going hand to hand in the field of computer technology. As with the development of faster and high capacity data memories we are able to use of much more computationally demanding methods than was possible previously. Earlier the ultrasound scanners were only used as an imaging system. In past and future, the development rate of ultrasound techniques has accelerated very fast. There was the time when the concepts of blood flow imaging and Tissue Doppler Imaging (TDI) were come into existence, and then measuring function or modality is started to include by the ultrasound scanners, by which the pure representation [1] of an image come into existence than was used earlier. Various numbers of methods progress have been triggered by the two concepts for the evaluation, such as strain and strain rate functional variables. The recent introduction of ultrasound transducers with three-dimensional (3-D) capabilities has enabled apparently more accurate translation of volumes, such as the volume of the left ventricle (LV). The ultrasound scanners have not only being use just for diagnostic purposes but it also have been used for treatment and monitoring of patient [2]. This all have become possible due to the functional variables of ultrasound. It is necessary that the measurements done by ultrasound scanners for treatment fellow-up or in monitoring situations should be correct and robust over time.

1.2 NOISE IN ULTRASOUND IMAGES

Digital images plays very significant role in our daily routine like they are used in satellite television, Intelligent traffic monitoring, handwriting recognition on checks, signature validation, computer resonance imaging and in area of research and technology such as geographical information systems and astronomy. Images are liable to variety of kinds of noises throughout their acquisition, processing, compression, transmission etc. It may be produced by the device and electronic equipment of a scanner or camera. In images, noise represents unwanted information that degrades the image quality. It may be outlined as associate undesirable product of image that adds extraneous information to a picture and is not a part of a picture [3] .

Speckle Noise in Ultrasound Images

Speckle noise is considered as multiplicative noise. It is a granular noise that degrades the nature of images got by active picture gadgets, for example, active radar and manufactured opening radar (SAR) images. Because of random changes in the arrival signal from a question in regular radar that is not large as single picture processing component, spot noise happens. It builds the mean dim level of a local region. Speckle noise makes picture translation troublesome in SAR images caused basically because of coherent processing of backscattered signals from different distributed targets. Speckle noise takes after a gamma distribution and the equation is as follows:

$$f(g) = \frac{g^{\propto-1}}{(\propto-1)!\,a^{\alpha}} e^{\frac{-g}{a}} \qquad (1)$$

where g is gray level of image and $a^{\propto}$ is a variance.

Speckle noise has following characteristics

- Speckle noise is multiplicative noise which is directly proportional to some gray level in image. [4]
- Speckle noise has statically independent noise and signal.
- Mean and variance of any pixel is equal to mean and variance of that local area.

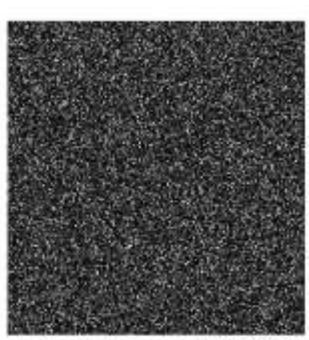


Fig 1: Speckled Noise Image

II. LITERATURE SURVEY

Buades et al. (2005) [5] proposed an algorithm known as non-local algorithm for image denoising that averages the intensities of the nearby pixels weighted by the similarity of image neighborhoods. This algorithm uses the idea of search window and similar patches within the whole image and provides prime quality image denoising results as compared to different filter. He also proposed a brand new performance metric known as method noise. The advantage of this filter is that it provides the noise free image of terribly high quality, with preserved structural details.

S. Sudha et al. (2009) [6] presented a wavelet-based thresholding plan for noise concealment in ultrasound images. In this work, quantitative and subjective correlations of the results acquired by the proposed method with the outcome accomplished from the other speckle noise reduction strategies show its higher performance for speckle reduction. By visual examination it is apparent that the denoised image, while expelling a generous measure of noise, endures basically no debasement in sharpness and details experimental results demonstrate that the proposed method yields fundamentally enhanced visual quality and better SNR compared to alternate systems in the denoising writing.

Fernanda Palhano et al. (2010) [7] presented a method for real-time denoising of ultrasound images: a changed version of the NL-means method is presented that incorporates a ultrasound committed noise show, and in addition a GPU implementation of the calculation. The proposed calculation was actualized utilizing GPU innovation and was compared to the C++ implementation, and additionally to the NL-means approach executed in the CUDA SDK. Results show that the proposed method is extremely productive in terms of denoising quality and is real-time.

Parul Sen, et.al, (2014) [8] proposed an efficient analysis of Ultrasound Image Denoising utilizing diverse kind of filtering methods. The search for efficient image denoising methods is as yet a valid challenge at the crossing of functional analysis and statistics. Image denoising has turned into an essential exercise in medical imaging particularly the ultrasound image. This paper proposes a medical image denoising calculation utilizing discrete wavelet transform, Weiner channel. The presence of noise in biomedical images is a major challenge in image processing and analysis. Denoising strategies are aimed at expelling noise or bending from images while retaining the original quality of the image.

Xu Mingliang et al. (2016) [9] presented the improved version of non local means algorithm by enhancing the weighted kernel function to denoise the various medical images. The process of medical images will introduce certain noises in the image. Furthermore, these noises will degrade the quality of an image and also affects the clinical diagnosis. Therefore, denoising plays an immense role in the pre-processing of medical image before the final treatement. It also proposed the parallel non-local means algorithm based on GPU. In PNLM threads are used because all the pixels work simultaneously on the window , for this purpose threads are used.The experiments performed in this research shows that the proposed method can have good performance on various levels of noise as compared to traditional algorithm and can achieve better results with higher efficiency.The PSNR , MSE and method noise of proposed method is better than NLM.

III. EXISTING ALGORITHMS

NLM and PNLM algorithm

The NL-Means algorithm is presented with the help of neighborhood filtering algorithm. In an image, similar rectangular areas can be present within the adjacent pixels. In a similar column, most of the pixels that are present contain similar rectangular areas. On the basis of noise minimization of similar rectangle area, the value of one pixel present in NL-means algorithm. Numerous enhancements are presented within the NL-Means algorithm such that the noise weighted kernel function can be enhanced and utilized in a medical image. Such enhancements can also be proposed on the basis of ensuring that high similarity areas have greater weight. The areas that have less similarity have less weight. Thus, the neighborhood pixels need to make sure that there are larger weighting coefficients given as output by them. There is an increment in the output depending on the minimization of distance. There is a need to select the matching kernel weight very carefully while denoising the quality of medical image. This algorithm also includes a programming model within it. Operation of each pixel is presented upon the execution thread. During the operation of parallel algorithms on those pixels, the complete image can be denoised in parallel manner at similar time duration. The image is to be copied from the host computer memory to the GPU device memory at the initial step. In the next steps, the signal pixel processing is executed in the GPU kernel. The denoising results are transmitted to the host memory in the last step. Following are the steps to be followed in this algorithm:

Step 1: On the host memory device of GPU memory area, the image and relevant parameters are copied from the computer.

Step 2: The following equation is calculated in order to compute the weight:

$$w(i,j) = \frac{1}{Z(i)} e^{\frac{\|v(N_i - v(N_j))\|_{2,a}^2}{h^2}} \qquad (2)$$

The next below given steps help in computing weights as:

Step 3: The Step 2 runs in iteration manner till the weights amongst the pixels and center pixel of each window are computed.

Step 4: The below equation gives the estimated value of gray pixels by:

$$NL(v)(i) = \sum_{j \in I} w(i,j) v(j) \qquad (3)$$

The denoising result is provided at the end.

Step 5: The denoising result is copied to the host computed from the GPU memory area.

IV. Proposed Work

This research work is based on to define the window size dynamically for the PNLM filtering. The PNLM filtering technique works with the noisy image, window size and quantity of noise in the image. The window size is defined statically to denoise the input image. In this research work, PCA (principle component analysis) algorithm is used to calculate textual features of the input image. The textural features of the image define the window size which is used for the image denoising. Linear Discriminant Analysis (LDA), Independent Component Analysis and PCA are a portion of the techniques utilized for feature extraction, among them PCA is intense method in image formation, Data examples, similarities and differences between them are identified effectively. The other principle advantage of PCA is dimension will be reduced by maintaining a strategic distance from redundant information, without much loss. Better comprehension of principal component analysis is through statistics and a portion of the mathematical techniques which are Eigen esteems, Eigen vectors. PCA is a valuable statistical and common method that has discovered application in fields, for example, image recognition and compression. Principal Component Analysis (PCA) is a mathematical methodology that utilizations linear Transformations to map data from high dimensional space to low dimensional space. The low dimensional space can be controlled by Eigen vectors of the covariance matrix.

The steps involved in PCA include:

• The mean valve S of the given data set "S" is found

• Subtract the mean value say from S. from these valves a new matrix is obtained. Let say "A"

• Covariance is obtained from the matrix i.e., C = AAT Eigen values are obtained from the covariance matrixes that are V1V2V3V4…VN,

• Finally Eigen vectors are calculated for covariance matrix C

• Any vector S or $S - \bar{S}$ or can be written as linear combination of eigen vectors shown in Equation below.

• Because covariance matrix is symmetric it form basis $V_1V_2V_3V_4 \dots V_N$,

$$V_N S - \bar{S} = b_1u_1 + b_2u_2 + b_3u_3 + \cdots + b_Nu_N \qquad (4)$$

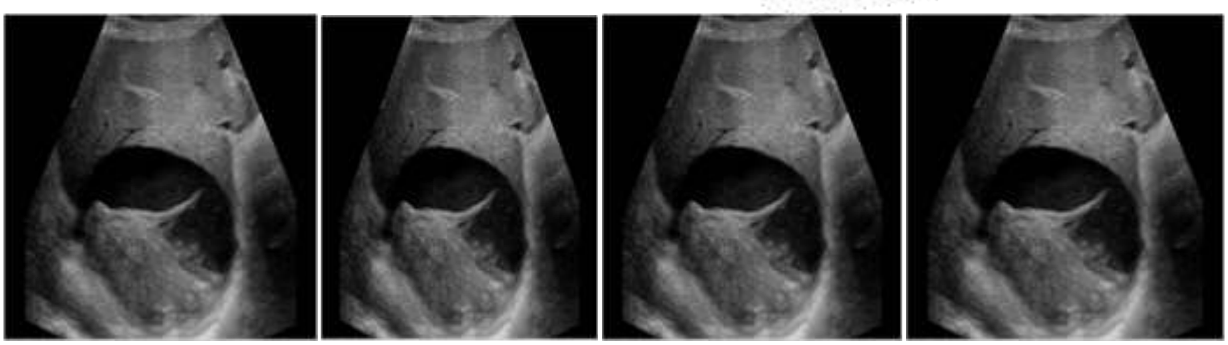
• Only Largest eigen values are kept to form lower dimension data set:

$$\hat{S} - \bar{S} = \sum_{I=0}^{1} b_1u_1 \,; 1 < N \qquad (5)$$

The components in lower dimension space are called principal components which are ensured to be independent just if the data set is mutually typically appropriated. PCA is delicate to the relative scaling of the original variables. Contingent upon the field of application, it is additionally named as discrete Karhunen-Loève Transform (KLT), or the Hotelling transform.

V. Experimental Results

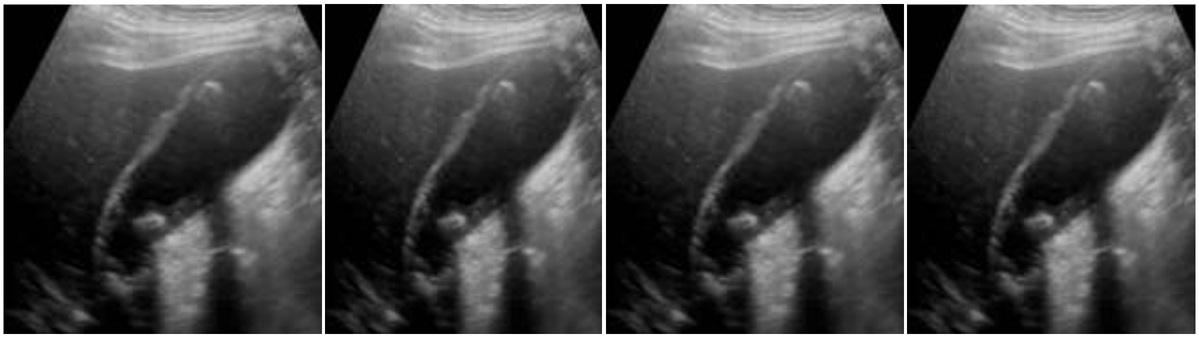
This research work, is based on to de-noise the ultrasound images. The images which are used for the experiment is taken from the web. [10] This site provide the large amount of the ultrasound images and these images contains the B-mode B-mode ultrasound images of common carotid artery in longitudinal section. In this research work, the NLM, PNLM and proposed PNLM algorithm is tested on the defined dataset images. The ultrasound images are taken from the different angles for the experiment purpose.



a. original image(Liver Cyst) b. NLM c. PNLM d. Proposed

Fig 2: Denoising of Liver Cyst Image.

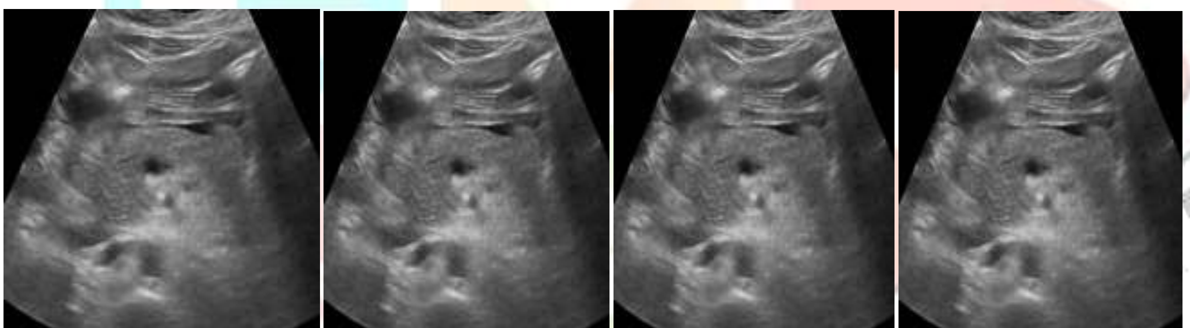
As shown in figure 2(a), the noisy image of Liver Cyst is taken as input which need to de-noise. The NLM algorithm is applied which shows that output in 2(b). The PNLM algorithm is applied which shows output in the 2(c) figure. The proposed algorithm is applied which shows output in the 2(d) figure.



a. original image (Gallstone) b. NLM c. PNLM d. Proposed

Fig 3: Denoising of Gallstone Image.

As shown in figure 3(a), the noisy image of Gallstone is taken as input which need to de-noise. The NLM algorithm is applied which shows that output in 3(b). The PNLM algorithm is applied which shows output in the 3(c) figure. The proposed algorithm is applied which shows output in the 3(d) figure.



a. original image (Pancreas) b. NLM c. PNLM d. Proposed

Fig 4: Denoising of Pancreas Image.

As shown in figure 4(a), the noisy image of Pancreas is taken as input which need to de-noise. The NLM algorithm is applied which shows that output in 4(b). The PNLM algorithm is applied which shows output in the 4(c) figure. The proposed algorithm is applied which shows output in the 4(d) figure.

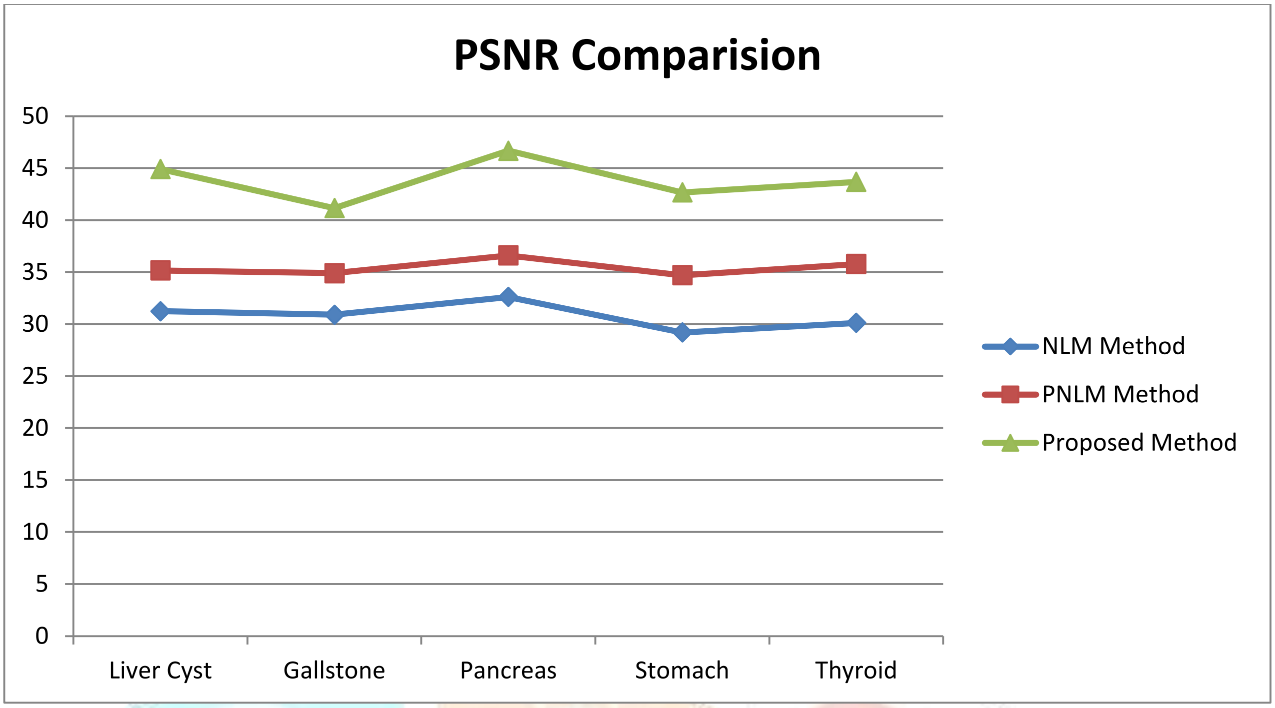


Fig 5: PSNR Comparison

As shown in figure 5, the three algorithms NLM, PNLM and proposed algorithms are compared in terms of PSNR. It has been analyzed that proposed algorithm performs well as compared to other NLM and PNLM algorithms.

Method Name	Liver Cyst	Gallstone	Pancreas	Stomach	Thyroid	Average
NLM Method	31.24	30.90	32.60	29.20	30.12	30.81
PNLM Method	35.16	34.90	36.60	34.70	35.78	35.42
Proposed Method	44.90	41.16	46.67	42.67	43.67	43.81

Table 1: Comparison of PSNR values

As shown in table 1, the three algorithms NLM, PNLM and proposed algorithms are compared in terms of PSNR. It has been analyzed that proposed algorithm performs well as compared to other NLM and PNLM algorithms.

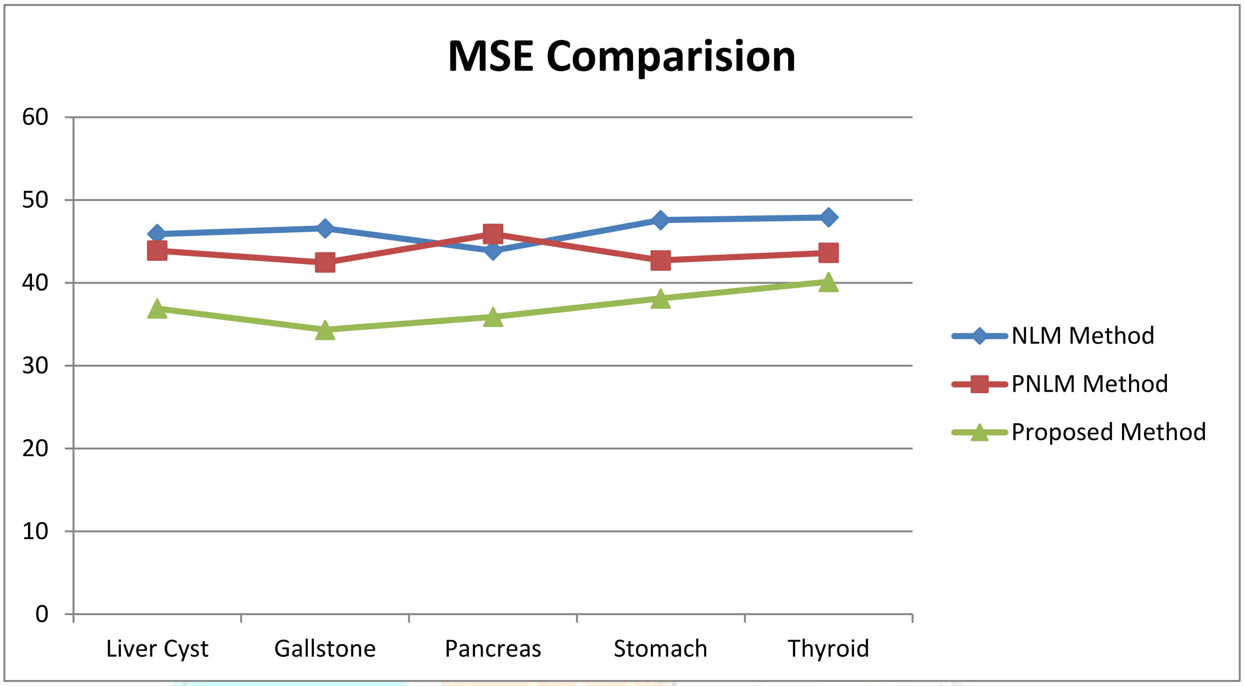


Fig 6: MSE Comparison

As shown in fig 6, the various algorithms NLM, PNLM and proposed algorithm are compared in terms of MSE. Due to dynamic defining of window size, MSE value is reduced of proposed algorithm as compared to other algorithms.

Method Name	Liver Cyst	Gallstone	Pancreas	Stomach	Thyroid	Average
NLM Method	45.89	46.56	43.89	47.56	47.90	43.36
PNLM Method	43.89	42.45	45.89	42.70	43.61	43.70
Proposed Method	36.89	34.34	35.90	38.12	40.13	37.07

Table 2 Comparison of MSE values

As shown table 2, the various algorithms NLM, PNLM and proposed algorithm are compared in terms of MSE. Due to dynamic defining of window size, MSE value is reduced of proposed algorithm as compared to other algorithms.

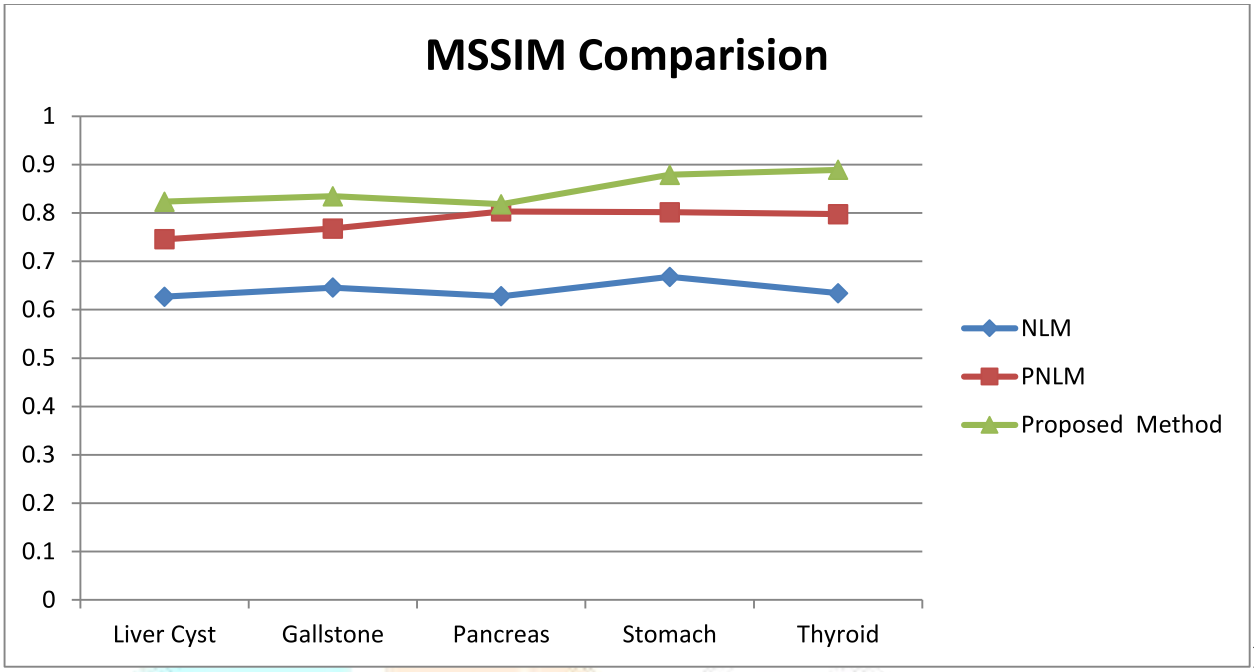


Fig 7: MSSIM Comparison

As shown in Fig 7, the NLM, PNLM and proposed algorithms are compared in terms of MSSIM values. It is been analyzed that proposed algorithm perform batter as compared to other two algorithm.

Method Name	Liver Cyst	Gallstone	Pancreas	Stomach	Thyroid	Average
NLM	0.6270	0.6456	0.6278	0.6680	0.6342	0.6405
PNLM	0.7456	0.7678	0.8031	0.8016	0.7975	0.7831
Proposed Method	0.8234	0.8345	0.8179	0.8789	0.8890	0.8487

Table 3: Comparison of MSSIM values

As shown in table 3, the NLM, PNLM and proposed algorithms are compared in terms of MSSIM values. It is been analyzed that proposed algorithm perform batter as compared to other two algorithm.

Conclusion

In this research work, it is concluded that ultrasound images has speckle noise which reduce image quality. The NLM and PNLM are the algorithms to denoise the ultrasound images. In this research work, PNLM algorithm is improved using PCA algorithm. The PCA algorithm calculate the window size dynamically for the image denoising. The proposed algorithm is implemented in MATLAB and results shows upto 20 percent improvement as compared to PNLM algorithm

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