International Journal of Advanced Computer Research (ISSN (print): 2249-7277 ISSN (online): 2277-7970)
Volume-2 Number-4 Issue-6 December-2012

Liver Ultrasound Image Analysis using Enhancement Techniques

Smriti Sahu[1], Maheedhar Dubey[2], Mohammad Imroze Khan[3]
[1,2]Department of Electronics & Telecommunication Engineering,
Chhatrapati Shivaji Institute of Technology, Durg, C.G (India)
[3]Department of Electronics & Telecommunication Engineering,
National Institute of Technology, Raipur, C.G (India)

Abstract

Liver cancer is the sixth most common malignant tumour and the third most common cause of cancer-related deaths worldwide. Chronic Liver damage affects up to 20% of our population. It has many causes - viral infections (Hepatitis B and C), toxins, genetic, metabolic and autoimmune diseases. The rate of liver cancer in Australia has increased four-fold in the past 20 years. For detection and qualitative diagnosis of liver diseases, Ultrasound (US) image is an easy-to-use and minimally invasive imaging modality. Medical images are often deteriorated by noise due to various sources of interferences and other phenomena known as Speckle noise. Therefore it is required to apply some digital image processing techniques for smoothing or suppression of speckle noise in ultrasound images. This paper attempts to undertake the study three types of the image enhancement techniques including, Shock Filter, Contrast Limited Adaptive Histogram Equalization (CLAHE) and Spatial filter. These smoothing techniques are compared using performance matrices Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE). It has been observed that the Spatial high pass filter gives the better performance than others for liver ultrasound image analysis.

Keywords

Liver disease, Ultrasound image, Image enhancement, Filtering, Histogram Equalization.

1. Introduction

In the last few years, huge parts of research have been carried out on the biomedical image Processing and analysis. It has been seen that biomedical image processing is used during monitoring of patients and for diagnostic purpose; therefore automatically processing systems are frequently required in medical image analysis. It is estimated that liver diseases are among the top ten killer diseases in India, causing lakhs of deaths every year. Since liver cancer is the sixth most common malignant tumour in the world and the third most common cause of cancer-related deaths worldwide. Hence, it is very important to produce a common standard tool, which is able to perform diagnosis with same ground criteria uniformly everywhere. Many doctors and many pathologists identify this problem.

In modern medical field, Ultrasound imaging is the most effective tool for diagnostics & treatment planning. It is used for imaging soft tissues in organs like liver, kidney, spleen, uterus, heart, brain etc [2], [3]. The processing of this image data have become an important option for health care in future.

Ultrasound images are often deteriorated by noise due to various sources of interferences and other phenomena known as Speckle noise [11]. Speckle noise is a multiplicative noise, which gives a grainy appearance in ultrasound medical images. Speckle noise is results from random fluctuations in the return signal, basically coherent processing of backscattered signals from multiple distributed targets. Its presence is often undesirable, since this creates difficulties in image interpretation and diagnosis. For removing such noise and to improve the interpretability or perception of information in images, we need to have efficient enhancement techniques like Shock Filter, Contrast Limited Adaptive Histogram Equalization (CLAHE), Spatial filter [4], [6]. These techniques are applied on the normal and diseased liver ultrasound images and to test the methods, a noise-free ultrasound image of a liver is taken as reference. To evaluate the effectiveness of enhancement methods, we have used the Peak signal to noise ratio (PSNR) and Mean Square Error (MSE) [5], [6]. The computational result showed that Spatial high pass filter performed better than others.

2. Research Methods

The principle objective of enhancement is to process an image so that the result is more suitable than the original image for analysis purpose. For early detection of liver diseases, we have applied image processing techniques. Here we concerned to Image Enhancement techniques and some of these are described below.

2.1. Shock Filter

Shock filter is used for deblurring signals and images by creates shocks at inflection points. Shock filters satisfy a maximum-minimum principle gives that the range of the filtered image remains within the range of the original image.

Shock filters apply either erosion or dilation process. The concept is that the dilation process is used near a maximum and an erosion process around a minimum. The decision between dilation and erosion is based on the signum function s in set {-1, 0, +1} based on the Laplace operator (Kramer-Bruckner, 1975). This process is iterated by using a Partial Differential Equation (PDE) according to a small time increment dt, which produces a sharp discontinuity called shock at the borderline between two influence zones and finally we get deblurred output. For better understanding, let us consider a continuous image f(x, y), then a class of filtered images $\{u(x,y,t) | t \geq 0\}$ of f(x, y) may be generated by evolving f under the process.

The Kramer and Bruckner definition can be expressed using the following PDE as [7] is given in equation (1):

$$u_t = -\text{sign}(\Delta u)|\nabla u| \qquad (1)$$

Where subscripts denote partial derivatives, and $\nabla u = (u_x, u_y)^T$ is the gradient of u as given in equation (2).

$$u(x, y, 0) = f(x, y) \qquad (2)$$

Above initial condition gives that the process starts at time zero with the original image. Let us assume that some pixels are in the influence zone of a maximum (negative Laplacian) i.e. $\nabla u = u_{xx} + u_{yy}$ is negative. Then a dilation given by equation (3) is

$$u_t = |\nabla u| \qquad (3)$$

For positive Laplacian, pixels belong to the influence zone of a minimum, with $\nabla u < 0$, then (2) can be reduced to an erosion equation i.e.

$$u_t = -|\nabla u| \qquad (4)$$

These two cases show that for increasing time, (1) increases the radius of the structuring element until it reaches a zero-crossing of Δu. Then a shock is produced due to meeting of the influence zones of a maximum and a minimum, which separates adjacent segments. Thus, the zero-crossings of the Laplacian serve as an edge detector [8], [9]. Basically the result is enhancement/sharpening of the input image.

2.2 Spatial Filter

Spatial filters are employed to remove noise from image data. Spatial filtering term is the filtering operations which performed directly on the pixels of an image. Spatial filters are used to produce smoothing effect, spatial mask are used for it [4] [12]. Spatial mask is nothing but a kind of finite impulse response filter (FIR filter), usually has small support 2x2, 3x3, 5x5, 7x7, this mask is convolved with the image.

The result is the sum of products of the mask coefficients with the corresponding pixels directly under the mask as shown in figure (1) and we get the filtered image [11]. If the operation is linear, the filter is said to be a linear spatial filter. Consider an image f of size $M \times N$ with a filter mask of size $m \times n$, the expression for linear filtering is given as in equation (5).

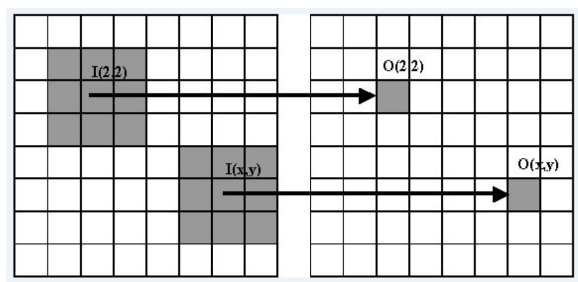

Figure 1: Masking Block

$$g(x, y) = \sum_{s=-a}^{a} \sum_{t=-b}^{b} w(s,t) f(x+s, y+t) \qquad (5)$$

Where a and b are nonnegative integer. The Spatial filter method applied by using two type of filter, Low Pass Filter (LPF) and High Pass Filter (HPF).This applying to choose the best guesses for enhancement image. We get different filtered output, based on the type of spatial filter used. The normal, benign, malignant Ultrasound images are used as test images to evaluate the efficiency of the developed algorithm.

2.3 Contrast Limited Adaptive Histogram Equalization (CLAHE)

Contrast Limited Adaptive Histogram Equalization (CLAHE) is a generalization of Adaptive Histogram Equalization and used to prevent the problem of noise amplification. In the case of CLAHE, the contrast limiting procedure is applied for each neighbourhood from which a transformation function is derived. This is achieved by limiting the contrast enhancement of AHE [6], [10]. One advantage is that the part of histogram which exceeds the clip limit is not discarded but redistributed equally among all histogram bins. The method has three parameters:

Block size: It is the size of the local region around a pixel for which the histogram is equalized.
Histogram bins: It is the number of histogram bins used for histogram equalization process. It should be smaller than the number of pixels in a block.
Max slope: It limits the contrast stretch in the intensity transfer function. Very large values will result in maximal local contrast.

The method takes in one additional parameter 'clip level' - which varies between 0 and 1. The method computes the histogram for each and every pixel and then does a equalization operation on the window or block size. After the pdf's for the bins are calculated, each one of them is checked if it is above the given clip level. If yes then the extra amount (pdf - cliplevel) is accumulated. After all the pdf's have been checked, the accumulated extra amount is uniformly distributed among all the bins. Thus when the pdf values are modified, they add to a cumulative distribution function (cdf). The cdf value is then mapped to an output intensity value (between 0 - 255). While in the case of AHE, pixels lying outside the image domain are padded with 0's.

3. Evaluation Parameters

To evaluate the effectiveness of enhancement methods, we have used the parameters PSNR and MSE [4, 11].

PSNR: The peak signal-to-noise ratio, abbreviated as PSNR, is the ratio between the maximum possible power of a signal and the power of corrupting noise, measure the degree of contrast enhancement. Greater PSNR is better as in equation (6).

$$PSNR = 10\log_{10}\left(\frac{Max_I^2}{MSE}\right) \tag{6}$$

Here, Max_I is the maximum possible pixel value of the image. For B bits per sample, Max_I is 2B−1.
MSE: The Mean Square error, abbreviated as MSE represents the cumulative squared error between the compressed and the original image. The lower the value of MSE, lower the error. MSE is given by equation (7):

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\left[x(i,j) - y(i,j)\right]^2 \tag{7}$$

Where x(i, j) noise-free m × n gray scale is image and y(i, j) is noisy approximation of x(i, j).

4. Results and Analysis

We have presented a comparative study of various enhancement techniques for Ultrasound image in terms of PSNR and MSE. All the simulations are done using MATLAB tool. The images taken as input shown in figure (2), figure (3) and figure (4) and corresponding comparison tables (1), table (2) and table (3) are given below:

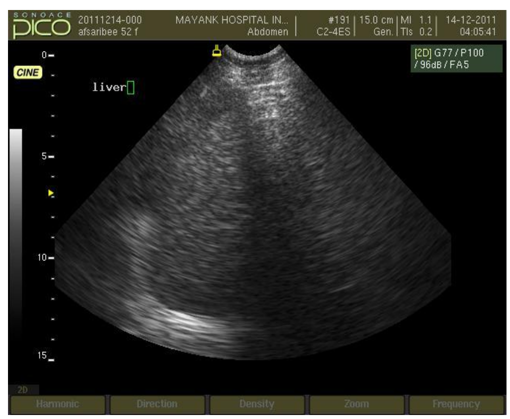

Figure 2: Normal Liver Image

Table 1: Performance of Various Enhancement Techniques for Normal Liver image

Type of Image	Enhancement Techniques	Parameters	
		MSE	PSNR
Normal Liver Image	Original Image	197.68	25.21
	Shock Filter	175.28	25.73
	Spatial LP	174.07	25.76
	Spatial HP	162.36	26.06
	CLAHE	180.95	25.59

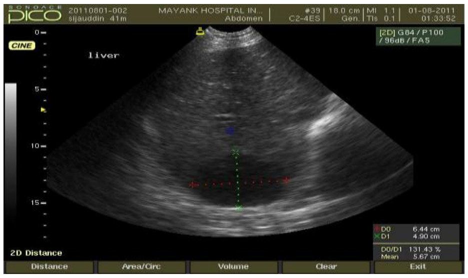

Figure 3: Benign Liver Image

Table 2: Performance of Various Enhancement Techniques for Benign Liver Image

Type of Image	**Enhancement Techniques**	**Parameters**	
		MSE	**PSNR**
Benign Liver Image	Original Image	197.96	25.20
	Shock Filter	176.47	25.70
	Spatial LP	173.31	25.78
	Spatial HP	164.09	26.01
	CLAHE	182.65	25.55

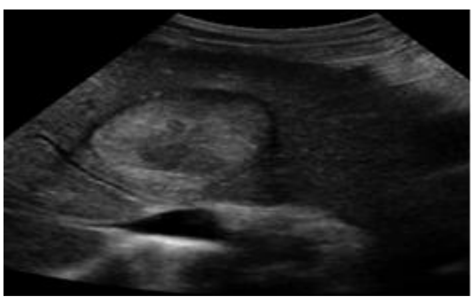

Figure 4: Malignant Liver Image

Table 3: Performance of Various Enhancement Techniques for Malignant Liver Image

Type of Image	**Enhancement Techniques**	**Parameters**	
		MSE	**PSNR**
Malignant Liver Image	Original Image	212.24	24.90
	Shock Filter	174.25	25.75
	Spatial LP	188.19	25.42
	Spatial HP	183.19	25.54
	CLAHE	187.01	25.45

5. Conclusion

This article compiles some of the image enhancement techniques used in the smoothing or filtering of speckle and other noises in ultrasound images. The comparison of all the studied methods is done based on quality metrics to test their performance. This comparison is helpful in determining best suited method for clinical diagnosis. By the given comparison table it is clear that Spatial High Pass filter gives the minimum MSE and highest PSNR value, and has given better performance than others. Therefore it is the best suited method. Accordingly, it gives better visual perception to sonographer for the liver disease diagnostic purpose. In future, we will try to find better methods of image enhancement. We will also concentrate on the other biomedical image processing approaches like segmentation, feature extraction.

References

[1] Katsutoshi Sugimoto, Junji Shiraishi, Fuminori Moriyasu, Kunio Doi, "Computer-aided diagnosis for contrast-enhanced ultrasound in the liver", World J Radiol 2010 June 28; 2(6): 215-223.

[2] Hisham Tchelepi, Philip W. Ralls, Randall Radin, Edward Grant, "Sonography of Diffuse Liver Disease", J Ultrasound Med 21:1023–1032, 2002.

[3] Hyun-Jung Jang, Hojun Yu and Tae Kyoung Kim, "Contrast-enhanced ultrasound in the detection and characterization of liver tumors", 2009 International Cancer Imaging Society, DOI: 10.1102/1470-7330.2009.0015.

[4] Vibhhrimali, R.S. Anand and Vinod Kumar, "Comparing the Performance of Ultrasonic Liver Image Enhancement Techniques: A Preference Study", IETE Journal of Research, Vol. 56, Issue 1, Jan-Feb 2010.

[5] H. K. Sawant, Mahentra Deore, "A Comprehensive Review of Image Enhancement Techniques," International Journal of Computer Technology and Electronics Engineering (IJCTEE), Volume 1, Issue 2.

[6] Wan Mahani Hafizah, Eko Supriyanto, "Comparative Evaluation of Ultrasound Kidney Image Enhancement Techniques", International Journal of Computer Applications (0975 – 8887) Volume 21– No.7, May 2011.

[7] Joachim Weickert, "Coherence-Enhancing Shock Filters," Pattern Recognition, Springer- 2003.

[8] R. Eveline Pregitha, Dr. V. Jegathesan, C. Ebbie Selvakumar, "Speckle Noise Reduction in Ultrasound Fetal Images Using Edge Preserving Adaptive Shock Filters", International Journal of Scientific and Research Publications, Volume 2, Issue 3, March 2012, ISSN 2250-3153.

[9] Cosmin Ludusan, Olivier Lavialle, Sorin Pop, Romulus Terebes, Monica Borda, "Image Enhancement Using a New Shock Filter Formalism", ACTA Technica Napocensis,

Electronics and Telecommunications, Volume 50, Number 3, 2009.

[10] Rajesh Garg, Bhawna Mittal, Sheetal Garg "Histogram Equalization Techniques for Image Enhancement" IJCSI International Journal of Electronics & Communication Technology, IJECT Vol. 2, Issue 1, March 2011, ISSN : 2230-9543.

[11] Md. Robiul Hoque Md. Rashed-Al-Mahfuz, "A New Approach in Spatial Filtering to Reduce Speckle Noise", International Journal of Soft Computing and Engineering (IJSCE), ISSN: 2231-2307, Volume-1, Issue-3, July 2011.

[12] Rafeal C. Gonzalez, et al, "Digital Image Processing," 2nd Edition, Prentice Hall, ISBN 0-201-18075-8, 2006.

Smriti Sahu received her B.E. degree in Electronics and Telcommunication Engineering, from Chhattisgarh Swami Vivekanand Technical University, Bhilai (C.G.) India in 2009 and pursuing M.E. in Electronics and Telcommunication from Chhatrapati Shivaji Institute of Technology, Durg, Chhattisgarh, India. Presently she is working as an Asst. Prof. in the Department of Electronics and Communication Engineering at Shri Shankaracharya College of Engg. and Technology, Bhilai. Her research interest includes Digital Image Processing, Biomedical Image Processing and Communication.

Maheedhar Dubey completed Master of Engineering in VLSI Design, currently working as an Assistant Professor in Electronics & Telecommunication Department in Chhatrapati Shivaji Institute of Technology, Durg, Chhattisgarh, India. He has 4 years of teaching experience. He has published / communicated 6 publications in National/ International Journals and conferences, also attended various workshops. He is the member of five professional societies like IEI, ISTE, IETE, ISCA, and IEEE. He has published four books & also one book published by an International Publisher of Germany.

Mohammad Imroze Khan received B.E. degree in Electronics & Telecommunication Engineering from Pt. Ravishankar Shukla University, Raipur, Chhattisgarh in 2005 and M. Tech. in Electronics Instrumentation from College of Engineering, Pune, Maharashtra in 2008. He has 3 years of teaching and 2 years of Industrial experience. Presently, he is working as a lecturer in Department of Electronics & Telecommunication, National Institute of Technology, Raipur. He has published / communicated 20 publications in National/ International Journals and Conferences. His research areas of interest are Image Processing, Embedded System, Cryptography and Network Security, Microprocessors & Microcontrollers.