Implementation of Cost Efficient Image Enhancement Technique Reduce Speckle in Ultrasound Images

Ms. Monika N. Dhole
Electronics Engineering, GHRCE
G.H.Raisoni College of Engineering
Nagpur, India
monikadhole065@gmail.com

Prof. Payal M. Ghutke
Electronics Engineering, GHRCE
G.H.Raisoni College of Engineering
Nagpur, India
payal.ghutke@raisoni.net

Abstract—Speckle is a granular multiplicative noise that reduces the resolution and contrast of the image there by degrading the diagnostic accuracy of the Ultrasound image. Speckle reduction technique has to be followed to enhance the quality of ultrasound image [3]**.**Speckle noise occurs in all coherent imaging systems, such as ultrasound images. The speckle noise in ultrasound images is often considered as undesirable and has a negative impact on clinical practitioners for diagnosis. Because of the signal-dependent nature of the speckle intensity, speckle noise in ultrasound imaging requires specific handling. So, any ultrasound speckle de-noising method must be designed in such a way that the speckle noise be suppressed without smearing the edges. In other words, any speckle de-noising method must preserve both the edges and structural details of the image and its quality [8].Digital image enhancement techniques are to improving the visual quality of images. Main objective of image enhancement is to process an image so that result is more suitable than original image for specific application. This paper presents real time hardware image enhancement techniques using field programmable gate array (FPGA) [10].It presents architecture for filters pixel by pixel and regions filters for image processing using Xilinx System Generator (XSG). This architecture offer an alternative through a graphical user interface that combines MATLAB, Simulink and XSG and explore important aspects concerned to hardware implementation.

Keywords—*Median filter, granular noise, ultrasound image, speckle reduction, histogram equalization, image pre-processing and post-processing units.*

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I. INTRODUCTION

Ultrasound imaging system is an important imaging Modality for the diagnosis of most pathology. However, in certain situations the accuracy of diagnosis can be altered due to the speckle noise that affects these images, which can lead to a misdiagnosis. Ultrasonic speckle noise is an interference effect caused by the scattering of the ultrasonic beam from microscopic Tissues in homogeneities [2].To curb this difficulty many de-speckling algorithms are being discussed in literature. Several adaptive speckle filters are proposed based on statistics extracted from the local environment of each pixel. These filters smooth speckle adequately, but they do not preserve details efficiently [2].

In medical imaging modalities, ultrasound imaging has been considered to be non invasive and most prevalent diagnostic tool for obstetric diagnosis, stones in kidney, imaging organs and soft tissue structures of the human body.etc. As ultrasound images are captured in real-time, they can show movement of the body's internal organs as well as blood flowing through blood vessels [1].Ultrasonagraphy is one of the simple and easily techniques in the diagnosis of diseases. The technique of ultrasonography involves transmitting ultrasound waves into the body from a small probe, which reads the return echoes, generating a picture of the inside of the body(that are recorded to visualize the structures beneath the skin). Medical images are usually corrupted by noise in its acquisition and transmission. In medical image processing, image denoising has therefore become very essential all through the diagnose. In certain cases, for example in Ultrasound images, the noise can restrain information which is valuable for the clinical practitioner. Consequently medical images are very inconsistent, and it is crucial to operate case to case [3].

One of the main shortcomings of ultrasound imaging is the comparatively poor quality of images, which are affected by speckle noise. The existence of speckle is unattractive since it disgrace image quality and it affects the tasks of individual interpretation and diagnosis. There are many methods used for early detection of disease diagnosis. But, ultrasound is relatively inexpensive, non-invasive, and can be performed in a regular clinical office outside of hospital settings. However, ultrasound image are often difficult to interpret because of the presence of speckle noise. Speckle is multiplicative noise and is mainly reason to make ultrasound image degenerate. The success and accuracy of ultrasonic examination depends on the Image quality. In case of ultrasonic images a special type of acoustic noise, technically known as speckle noise, is the major factor for image quality degradation [3].

Ultrasonic speckle is an interference effect caused by the scattering of the ultrasonic beam from microscopic tissue in homogeneities the resulting granular pattern does not correspond to the actual tissue microstructure. On the contrary, speckle tends to mask the presence of low contrast lesions and reduces the ability of a human observer to resolve fine detail. Hence, speckle suppression by means of image processing techniques should improve image quality and possibly the diagnostic potential of medical ultrasound imaging. The conventional noise cleaning algorithms fails to reduce the noise in ultrasonic images. The reason behind this is, although the ultrasonic images are heavily corrupted by noise, they possess sharp contrast, which should be retained. In addition, they contain a variety of features, which should also be preserved. These include bright large-scale interfaces between organs such as small blood vessels with dimensions

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comparable to the average speckle size and, more importantly, boundaries between areas of slightly different gray-scale level, which enable the physician to detect abnormalities such as tumors. Linear filters are not suitable for this type of images because they introduce severe blurring and loss of diagnostically significant information [3].

II. METHODOLOGY FOR PROPOSED HARDWARE IMPLEMENTATION

Image enhancement technique needs to be implemented on hardware in order to meet the real time applications. FPGA implementation can be performed using prototyping environment using Matlab/Simulink and Xilinx System Generator tool. The design flow of hardware implementation of image enhancement technique is shown in fig.1. image source and image viewer are simulink block sets by using these blocks image can give as input and output image can be viewed on image viewer block set. Image pre-processing and image post processing units are common for all image processing application which are designed using simulink block sets [5].

Image pre-processing unit: The gray image is in 2D array size such as R*C where R, C represent row and column of an image respectively. For XSG implementation, the image must be converted into 1D data array. Image pre-processing block is used to convert the 2D image data into 1D data array which is shown in fig.2. Image pre-processing block includes, The Transpose block transposes the R*C into image matrix into C*R sized matrix, Convert 2-D to 1-D block reshapes a C*R matrix to a 1-D vector, Frame conversion block set the output signal to a frame based data and provided to unbuffer block, unbuffer block which converts this frame to scalar samples output at a higher sampling rate [4].

Image post-processing unit: Image post processing block is needed to reconstruct the 1-D array into 2-D image which is shown in fig.3. This block includes Buffer changes input sequence into smaller or larger frame size. The buffer block redistributes the input samples to a new frame size. The convert 1-D to 2-D block changes 1-D vector data into 2-D data of size C*R matrix. The transpose block transposes the C*R input image matrix into size R*C. The data type is converted using data type conversion block [4].

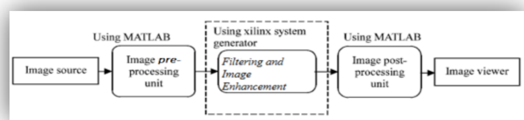

Fig.1. Design flow for hardware implementation of image enhancement

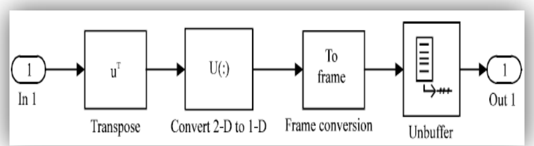

Fig.2. Image pre-processing unit

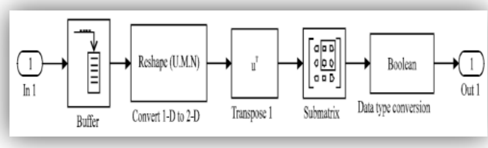

Fig.3. Image post-processing unit

Enhancement Algorithm:

A. Pre-processing- Median Filter:

Median filtering is a nonlinear filtering method which is used to remove the 'speckle' noise from an Ultrasound image. It assigns to each pixel the median value of its neighbourhood. The median is calculated by first sorting all the pixel values from the surrounding neighbourhood into numerical order and then replacing the pixel being considered with the middle pixel value. This filter is relatively slow, even with fast sorting algorithms such as quick sort. It does not blur the contour of the objects [3]. It performs digital filtering technique. Noise reduction is a typical pre-processing step to improve the results of later processing [6].

B. Histogram Equalization:

Histogram equalization is a method in image processing for contrast adjustment. It is one of the most popular, computationally fast and simple to implement techniques for contrast enhancement of digital images. A histogram is a graphical representation of the distribution of data. An image histogram is a graphical representation of the number of pixels in an image as a function of their intensity. The histogram equalization technique is used to stretch the histogram of the given image. Greater is the histogram stretch greater is the contrast of the image. In other words if the contrast of the image is to be increased then it means the histogram distribution of the corresponding image needs to be widened [6]. Histogram equalization is the most widely used enhancement technique in digital image processing because of its simplicity and elegancy. This method is useful in images with backgrounds and foregrounds that are both bright or both dark [7].

III. SIMULIN MODEL

Matlab is a tool used for algorithm development and analysis of the data. The Image Enhancement Algorithm has been extended to the Matlab model. Simulink is a graphical tool which allows the user to graphically design the architecture and perform simulation. Simulink helps to build up the models from libraries of pre-built blocks. Xilinx System Generator (XSG) for DSP is a tool which offers block libraries that plugs into Simulink tool. Xilinx System Generator is a DSP design tool from Xilinx that enables the use of the Math works model-based design environment Simulink for FPGA design. It extends Simulink in many ways to provide a modeling environment that is well suited to hardware design. The tool provides high-level abstractions that are automatically compiled into an FPGA at the push of a button. All of the downstream FPGA implementation steps including synthesis and place and route are automatically performed to generate an FPGA programming file. System Generator provides many features such as System Resource Estimation to take full advantage of the FPGA resources, Hardware Co- Simulation and accelerated simulation through hardware in the loop co-simulation; which give many orders of simulation performance increase [6].

IV. PARAMETERS

In order to assess the quality of the reconstructed ultrasound images; three recent evaluation metrics are used: Peak Signal-to-Noise Ratio (*PSNR*), Coefficient of Correlation (*CoC*) and Speckle Suppression Index (SSI). PSNR is fairly simple to calculate and is a measure of error between original image and de-noised image. Another parameter that measures detail preservation is Coefficient-of-Correlation (*CoC*) which is basically the correlation between original image and the output image .Higher values of all these parameters indicate better quality of de-noised images. The values of performance parameters are obtained at various noise variances in increasing order. The proposed de-speckling filter maintains a high degree of *CoC* and *PSNR* at lower noise variances. At higher noise variances, performance of the proposed technique is much better. Another specific metric is utilized known as Speckle Suppression Index (*SSI*). Lower value of *SSI* indicates that large amount of reduction in speckle level on the speckled ultrasound images. The performances of the proposed method are quantitatively measured by Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE) values [5].

$$MSE = \frac{1}{MN} . \sum_{i-1}^{M} \sum_{j-1}^{N} (R_{ij} - I_{ij} .)^2$$

Where, I is the input image and R is recovered image and M, N is the size of the test image. Using MSE, Peak signal to noise ratio will be calculated.

$$PSNR = 10 \log_{10} \left[\frac{g_{\max}}{MSE} \right]$$

Where,

gmax =255 (Maximum gray Level)

V. PROPOSED WORK

In this paper we are concentrating on reducing the speckle noise i.e. present in ultrasound images using various techniques such as image pre-processing unit, median filtering, Histogram Equalization, image post-processing unit. So the proposed FPGA implementation of image enhancement technique is new in this area.

Real time image enhancement of ultrasound images with Spartan 3-E FPGA kit using Xilinx system generator with Matlab/Simulink is not yet implemented so far. The results obtained from the Xilinx/Simulink model are faster. In our model, the interfacing of Matlab and XSG will be done through the workspace of Matlab to obtain better results with high speed. The Image Enhancement will be performed on Matlab/ Simulink Model and it will be verified on Spartan-3E FPGA.

VI. CONCLUSION

This paper presents real time hardware image enhancement techniques using field programmable gate array (FPGA). This architecture offer an alternative through a graphical user interface that combines MATLAB, Simulink and XSG and explore important aspects concerned to hardware implementation. Using Xilinx Spartan 3-E FPGA kit implementation cost will be reduced, making the system cost efficient.

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