Reduction of Ultrasound Imaging Artifacts

Kauther Saleh Mohammed Al-Saqri[a] and Sumesh Eratt Parameswaran[a]

Nowadays, with the development of medicine and medical equipment, medical imaging has become an important part in health care sector. Doctors can diagnose diseases using medical imaging without making cut/wound in the human's body; ultrasound is efficiently used because of its low cost and non-invasive nature and produces good quality images. However, artifacts are a common occurrence in an ultrasound display such as degraded, ambiguity, resolution etc. These artifacts affect the diagnosis accuracy. Thus, artifacts reduction in medical image is essential. In this paper, we describe and study medical image's artifacts reduction techniques. Different image enhancement techniques for removing different types of artifacts without losing the fine details are studied to produce enhanced images. These reduction techniques are implemented using Matlab. The main objective of this project is to improve the quality of the medical images in order to help doctors to make better diagnosis decisions. This proposed work is expected to be very useful and efficient to use.

Keywords: Artifacts; Medical image; Wavelet transform; Image processing.

Introduction

Ultrasound imaging is a sound wave with a high frequency in range of 1-20 MHz. It is used for medical diagnosis to visualize inside the body of a patient without making cut/wound in the human body; doctors use it to view swells, cyst, heart or any other organs [1]. Ultrasound is widely used because of its low cost, non-invasive nature and it produces good quality images. However, some images may include artifacts from the surrounding environment, the test equipment or background tissue. These artifacts make the image diagnosis difficult. For this purpose, artifacts reduction is very important in medical images. Reduction of ultrasound imaging artifact is a system that will help in reduction of artifacts from ultrasound images without losing the medical diagnosis. This work will be focusing on reduction of the different types of the commonly occurring artifacts in medical images. Also, it will improve the quality of an image [2]. This system will depend on an algorithms that reduce the artifacts from the medical image and then compare the new image with the original image to make sure that no significant loss of the fine details and more enhanced image is produced finally.

A. Existing work

For over a half century, ultrasound has been used to view inside the human body. The first person to use ultrasound device as medical diagnostic is Dr, Karl Theo Dussik an Austrian neurologist who used it to capture the image of brain. Nowadays ultrasound is the most widely used tool in medical field, because of its efficiency and inexpensive compared to other imaging devices like; Magnetic Resonance Imaging (MRI) and others. Ultrasound sound waves are in the range of 1-20 MHz, which is high frequency waves to be used and these frequencies has a short wavelength that offers high resolution of image, while the low frequency waves has longer wavelength it offers images of low resolution. Ultrasound transducer will transmit sound waves echo into the body, which works as a speaker, at the same time it will receive sound waves, which works as microphone [3], maintaining the integrity of the specifications

P.C.Tay, et all [4] explained that multi-path reflection and reverberation artifacts are a common problem in ultrasound image. In this paper the method used is to remove these artifacts. The regions that are affected by these artifacts are placed with textures that take after the underlying objects. This method uses soft thresholding with 2D discrete wavelet transform of the artifact regions and locales to create a close ideal gauge of the reflectivity values due just to the reverberation and multi-path reflection artifacts. Just subtracting this estimate from the first reflectivity values, it achieves a close ideal estimate of the artifact free reflectivity values. They provided simulated and B mode pictures to substantiate the advantages of this method in creating an artifact removed image [4].

Background

Another problem in ultrasound images is that some type of noises can affect the images quality, the most common type occurring in medical image is speckle noise [5], and this noise can be reduced by using several methods. A modified form of

Morphological Image Cleaning (MIC) algorithm is used to reduce the noise, this algorithm use a technique to reconstruct the features that are lost while reducing the noise also histogram is not required for calculating the threshold of the image. The results that are produced by this algorithm in image quality and time complexity is better compared to the original MIC [6].

Missing structure in another type of artifact, and this type occur for numerous reasons and can be related to the resolution of the ultrasound image. The capability to differentiate between two distinct structures that are in close proximity is defined as resolution. Lateral resolution or the capability to differentiate between two objects in a horizontal plane, is related to the width of band of the ultrasound beam. If two structures are closer to each other than the width of the lateral resolution, they will seem as single image, so the display is missing. Specialists can improve the resolution by increasing the frequency or change the area of interest to the focal zone and decrease the overall PSNR [7]. Another artifact that may also produce missing Image is Acoustic shadowing. This artifact occurs when the beam of ultrasound reaches a strong reflector and this reflector will decrease the beam intensity to distal structures, basically blocking the beam to that area. Hence, any image that lies deep to the strongly reflecting item cannot be visible [7].

The opposite of Acoustic shadowing is Enhancement artifact. It happens when the beam of ultrasound meets a weak reflector or is weakly attenuated by an object in its path. Meanwhile the returning echoes distal to such feebly attenuating structures are of higher amplitude than different structures at comparable depth, the system incorrectly shows them as areas of expanded echogenicity. Decreasing time-gain remuneration in areas of enhancement on the 2D image can lessen the presence of enhancement artifact. Enhancement is normally encountered at the limits of the ventricular wall and the pericardium [8].

An image with poor quality is denoted as degraded image artifact and is frequently due artifact phenomena. A type of image degradation is reverberation. They are considered as secondary reflections that occur along the path of a sound pulse and are an outcome of the ultrasound bouncing between the structure and another reflecting surface. Reverberations show up as parallel yet irregular lines reaching out from the object far from the transducer. They happen when either the close side of the object, a second object, or the transducer itself works as another reflecting surface. The repeated journeys traveled by a similar beam deliver extra signals that are interpreted as a similar objects at least two similarly disposed reverberate signals at expanding profundities. In general reverberations happen with superficial, strong reflectors, for example, metallic objects and calcified structures. Reverberation artifact has two subtypes:

a) Comet tail artifact.
b) Ring down artifact [7]

a. Department of Electronics and Communications, Middle East College, Muscat, OMAN

Range ambiguity appears in the display of the right structures in the wrong area. It happens with high pulse line. In this way the machine can't perceive the returning signal as beginning from the first or second or even a resulting pulse. This outcome in deep structures seeming nearer to the transducer than their actual area. At the point when unexpected object is seen in a heart chamber, it is regularly because of range ambiguity [7].

After reading papers about several types of artifacts and methods to remove artifacts in medical images. It is very repetition frequency. With a high PRF a second pulse is conveyed before the first Doppler signal along a similar scan important to recognize these artifacts as it may lead to erroneous interpretation of the image and surely it will impact the clinical decisions, an understanding on how to proceed in the project and which method should be used for improving the quality of the ultrasound image without losing the information or any fine details and without any artifact.

Design and Implementation

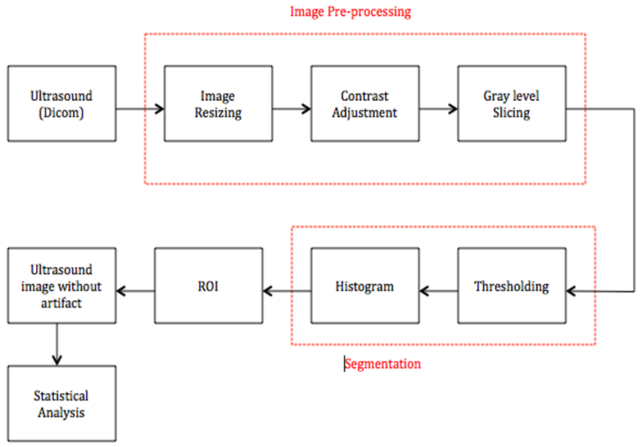

Figure. 1. System block diagram

Fig. 1. represents the block diagram of the system. As an input it will be ultrasound image (512x512). In image pre-processing the aim of this block is to improve the image data that suppresses any unwanted distortion and enhances some image features for further processing. Construct enhancement, segmentation, extraction and thresholding can be done. Soft and hard thresholding are used to reduce the artefact from the ultrasound image. The aim of image restoration block is to undo or compensate for defects, which degrade an image.

B. Design Steps

The design steps followed are:

1. Convert image to other format (dicom).
2. Read image.
3. Filter the image using wiener filter, median, etc.
4. Apply wavelet transform to decompose image.
5. Apply filtering on the decomposed image-using threshold to denoise the image.
6. Reconstruct the image using inverse wavelet transform.
7. Get the enhanced image.

C. Design and Analysis

The following steps are followed

Input data: In the first step the original ultrasound image is saved in the database before analyzing and remove the annotation that is in the image using DICOM viewer, then convert the image format from dicom to JPG, as MATLAB does not read image in dicom format, then input them during the analyzing form. Therefore, the input will be ultrasound image that contains range ambiguity artifacts

Pre-processing step: The aim of this step is to make an improvement to the ultrasound image data, to enhance image features for further processing or suppress any unwanted distortion. This stage covers the sub stage that was done in the project for example: image resizing, contrast adjustment and gray level slicing.

Segmentation: This process is done to divide the image into multiple parts, to simplify or change the demonstration of the image to make it easier to analyze. It is typically used to recognize objects or other important data in ultrasounds image. This stage is divided into sub stage:

Thresholding: Apply the threshold using a global thresholding value (Otsu's method). It will replace each pixel in an image with a black pixel if the image intensity is less than threshold value, and replace white pixel if the image intensity is greater than threshold. Then convert to binary image.

- Measure proprieties of image region
- Plot Bounding box.
- Extract objects: it extracts the interesting regions of an image.

ROI: It displays the region of interest of an ultrasound image.

Statistical analysis: The values of Mean square Error and Peak-Signal to Noise Ration are displayed on the command screen after execution of the codes in the previous stages. The PSNR is calculated as: $10\log_{10}(\frac{255^2}{MSE})$, where MSE (Mean Square Error) is used to measure the quality change between the original image and enhanced image, it is computed by: $MSE = \frac{1}{N^2}\sum_{ij=0}^{N-1}(X_{ij} - Y_{ij})^2$. The PSNR will be higher for a good quality image and lower for poor quality image. It measures image loyalty, that is, the manner by which nearly the changed images takes after the original image [2].

Results and discussion

The system was designed is such a way that it displays the image after every major process in the image processing. Below are the results of the steps:

Figure. 2. Original Image

The first step is to display the original image shown in figure 2, which has been selected by the user. To read the image and display it in Matlab the commands are used, [I=imread('ultrasound.jpg')], [imshow(I)]. Then it is taken as input into the system. To display histogram of the image this command is used [imhist (I)] which is shown in figure 3.

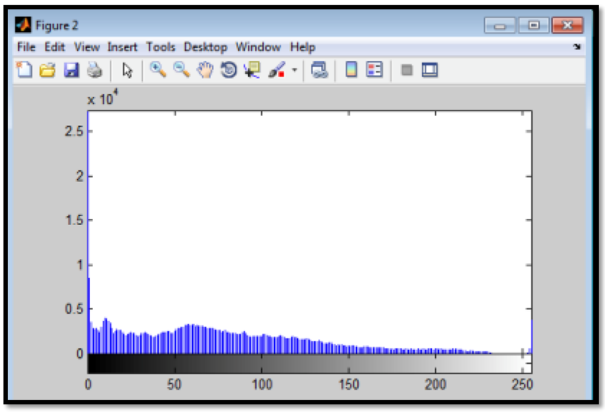

Figure. 3. Histogram of the original image

Contrast enhancement is done in the pre-processing step. This tool was used to change the brightness or contrast of an image. In this step, by the use of this command [i5=imcomplement (I)], it takes the complement of the binary image, ones become zeros and zeros become ones, that is dark areas will become lighter and light areas will become darker. Increase the contrast to find the appearance in a good manner.

Next level is grey level slicing. The main objective of gray level slicing with background is to display the region of interest, shows high values for the range of interest and original gray level values in other areas. In this step, first compute the global threshold, to calculate threshold using (threahold=graythresh (I)). Then convert the to a binary image using (I=im2bw (I, threshold)). It will replace each pixel in an image with a black pixel if the image intensity is less than threshold value, and replace white pixel if the image intensity is greater than threshold. Next step to get this result image without artifact, all object that are fewer than 30 pixels have been removed using (I=bwareaopen (I, 30)), and results another binary image and the region of interest (ROI) has been identified by the green rectangles shown in figure 4.

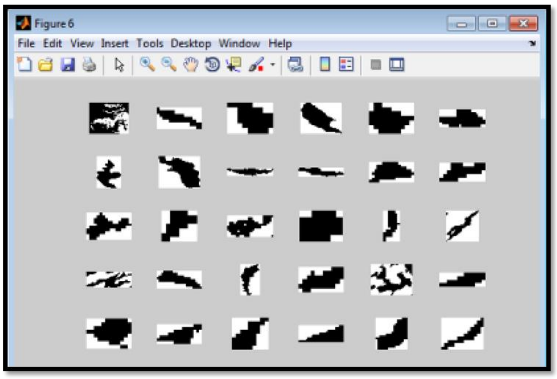

Figure. 4. ROI extractions

In figure 4, objects has been extracted, in other words each region of interest that was selected in the ultrasound image has been extracted and displayed.

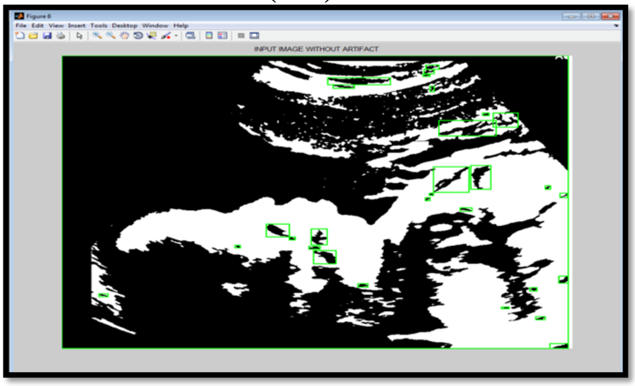

Figure. 5. Final result

In figure 4, the final result of the image is shown. The system provided good quality of the image with PSNR= 49.0215% without losing any important information.

Subsequent to having a detailed research on different papers, articles, journals, websites etc. it was found that there are several ways to enhance medical imaging by removing unnecessary artifacts. In the literature review that was mentioned is to remove different type of artifacts such as, reverberation, multi-path etc. The most common way to improve the quality of the image is by thresholding method. The thresholding method is used in this project to remove the artifact that appears in the ultrasound image and this artifact makes it difficult for the doctors to diagnose any problem.

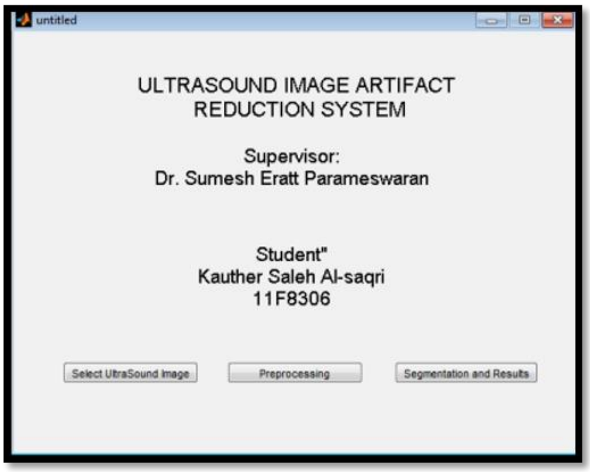

Figure. 6. GUI

By using Matlab program the results are obtained and the image quality has been improved and the artifact was removed and there is no unnecessary range ambiguity that appearing in the image. The GUI of the work is shown in figure 6.

The main problem faced during the implementation of the work was the lack of information about ultrasound imaging artifact and how it appears and why, also on how to remove the common types that appears in the image. The major problem in ultrasound image is range ambiguity where results in various artifacts in the ultrasound image, such problem can be avoided by using level set thresholding for providing enhanced image that shows all the important information that might be missing in the original one. In addition to this there are technical problems, which they are:

- Cannot resize image to small size, as there might be details that are not considered, and it gives ambiguity. To solve this original size is used.
- The enhancement of image is required to show the features of image. To solve this contrast adjustment is done to image viewed in a good manner.
- Original ultrasound image has certain regions that are not visible. Applying threshold method through bounding box illustrates important information of image.
- When applying high threshold it destroys the image and lose all important information, and when applying low threshold the image still contains artifact. Therefore, to solve this a minimum threshold was applied that preserved the important details.

Conclusion

On comparing the outcomes of the system with the predicted objectives, this work provide accurate diagnose by avoiding range ambiguity artifact in ultrasound images. To obtain objective quality assessments through image metrics and identify method which provides better performance to reduce range ambiguity artifact. The results after implementing the system, by using Matlab software, it is effectively removing ultrasound-imaging artifact and define the region of interest. The quality of the image was improved as the PSNR ratio of output to input was found with two significant values 49%, 9.6% respectively. Thresholding method is effectively done by removing unnecessary ambiguity artifact in the image.

References

[1] "General ultrasound in the critically ill", 2017. [Online]. Available: https://www.radiologyinfo.org/en/pdf/genus.pdf.

[2] P. Hiremath, P. T. and S. Badiger, "Speckle Noise Reduction in Medical Ultrasound Images", Advancements and Breakthroughs in Ultrasound Imaging, 2013.

[3] A. Perlas and V. Chan, "Ultrasound Imaging of Brachial Plexus: In Reply", Anesthesiology, vol. 100, no. 5, pp. 1326-1327, 2004.

[4] P. Tay, S. Acton and J. Hossack, "A wavelet thresholding method to reduce ultrasound artifacts", Computerized Medical Imaging and Graphics, vol. 35, no. 1, pp. 42-50, 2011.

[5] S. Sudha, G. Suresh and R. Sukanesh, "Comparative Study on Speckle Noise Suppression Techniques for Ultrasound Images", International Journal of Engineering and Technology, vol. 1, no. 1, pp. 57-62, 2009.

[6] T. Jeyalakshmi and K. Ramar, "A Modified Method for Speckle Noise Removal in Ultrasound Medical Images", International Journal of Computer and Electrical Engineering, pp. 54-58, 2010.

[7] T. Yo and Y. Etsuji, "Method for eliminating motional artifacts in magnetic resonance imaging", Magnetic Resonance Imaging, vol. 13, no. 6, 1995.

[8] A. Pamnani and N. Skubas, "Imaging Artifacts During Transesophageal Echocardiography", Anesthesia & Analgesia, vol. 118, no. 3, pp. 516-520, 2014.