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A Comparison of the Quality of the Long Bone Fracture Images Produced by a Conventional Ultrasound Machine before and after Implementing the Migration Method Using MATLAB Software

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***Abstract**: In this paper, the migration method, which is originally used in seismic imaging, was used in the post-processing of the long bone fracture images acquired by a conventional ultrasound machine. The method was implemented using the wiener filter encoded in MATLAB software using the image processing tool box to bring about image restoration. Analysis of the images' Peak Signal to Noise Ratio was then done before and after the migration method was implemented and comparisons were made. It was observed that there was an improvement in the peak signal to noise ratio, which corresponds to an improvement in the quality of the reconstructed images. The mean and variance of the same images were also studied and analyzed.*

Keywords— Ultrasound, long bone, fracture, imaging, migration method

1. INTRODUCTION

Ultrasound imaging modalities have received considerable attention in bone imaging application in the recent past. They have been proposed and tested for the detection of bone defects, as intra-operative aiding tools in orthopedic procedures. Recent developments combined with the availability of new image and data processing methods to extract bone surface information is now making ultrasound imaging a more steadfast and usable modality for 3D bone imaging [1].Assessing long bone using ultrasound remains a prominent research area as they are the most commonly fractured bones. Although most of the research is in long bones, application of this imaging modality to knees, rotator cuff and spine are currently being investigated.

However, ultrasonic attenuation and imaging artifacts make the accurate detection of bone surfaces in an ultrasound image very challenging. It becomes evident that the intensity of the ultrasound waves alone is inadequate to differentiate between bone surface and other soft tissue structures and that more imaging features need to be used in order to identify a bone surface in ultrasound imaging. The shadow region below the bone surface is one of the features that have been proposed. Long bone fractures are among the most common injuries sustained by both young and old people. Therefore, fracture diagnosis and healing monitoring are vital. Ultrasound diagnostic modality is emerging as an alternative to conventional X-ray radiography for evaluating fractures and monitoring the healing process due to its advantages of being portable, noninvasive, quick, and inexpensive. For pediatric long bone fracture, ultrasound does not necessitate exposing children to ionizing radiation, which has been greatly linked to affecting DNA composition, which leads to cancer. In addition to that, ultrasound does not require serious prior preparation of the patient and can be used on trauma patients without worrying about their health background. Garcia in 2013 proposed the Stolt F-k migration method to process the signal measured by axial scanning and oblique cracks in the cortical long bone plate, which illustrates the potential for better image resolution for ultrasound imaging [1]. However, it was limited because it considered constant reflective velocities and parallel beams of the sound received by the transducer. These methods generated blurred and inaccurate images and couldn't detect fractures with a width of less than 1 mm. The robustness and accuracy of imaging cortical long bone fracture using migration method encoded in MATLAB are evaluated in this paper. From the related work done by the previous researchers, the migration method has been used in seismic imaging and it has been done in the preprocessing of the image, which imposes heavy computational load and high computational power on the machine. However, in this paper, the researchers investigate the ultrasound fracture bone imaging using the migration method encoded in MATLAB software, which is done in the post-processing of the image obtained by the conventional ultrasound machine.

2. METHODOLOGY

Three volunteers were used for this study. Volunteer 1 had fractures on both the tibia and fibula in the lower left limb. Volunteer 2 had a radius fracture in her left hand, and Volunteer 3 had a tibia fracture in her lower right lower limb. An in vivo experiment was carried out using a conventional Philips diagnostic ultrasound system. This system uses a 39-mm real-time linear array transducer with 288 elements and a 5–17 MHz bandwidth. Acquisitions were performed using a transmission frequency of 5 MHz in this frequency band, no significant attenuation was observed in the visualization of the soft tissue-bone interface. The near, far field, and gain control buttons were adjusted to set the focus of imaging at the location of the soft tissue-bone interface. The images obtained are them post- processed using migration method which is

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encoded in MATLAB software. An algorithm was written using the flow chart below.

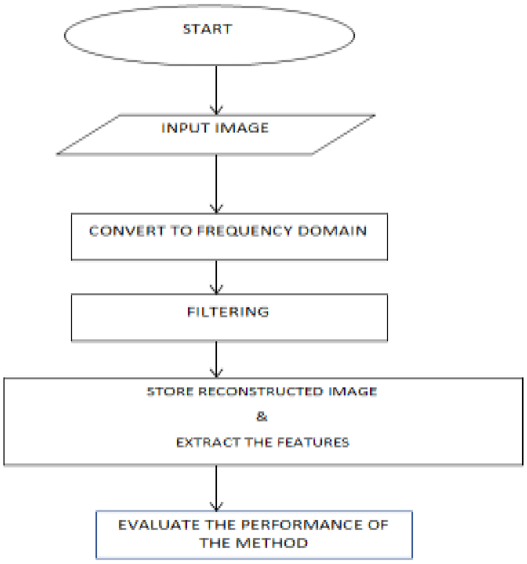

Figure 1: Flow chart of the Algorithm used

In this research, the wiener filter was used for image restoration. Nilsen & Holm showed that implementing the wiener filter produces an image equivalent to multiplying a coherent factor with the conventional delay and sum beaming, thus bringing about the effects of the migration method [3]. A Butterworth high pass filter was also used to filter out the frequencies that were not relevant to our study. MATLAB codes were written to extract the Peak Signal to Noise Ratio, mean and variance of the images which are used in the comparison and analysis of the quality of the reconstructed images.

3. Results and Analysis

The following are the images that were obtained before and after the migration method was implemented.

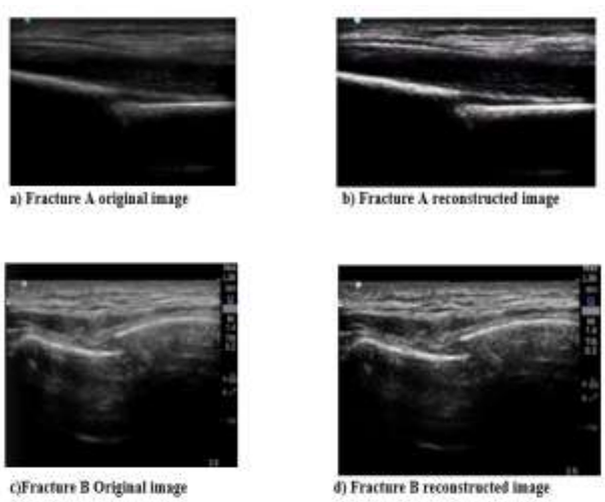

Figure 2: Fractures A and B before and after reconstruction.

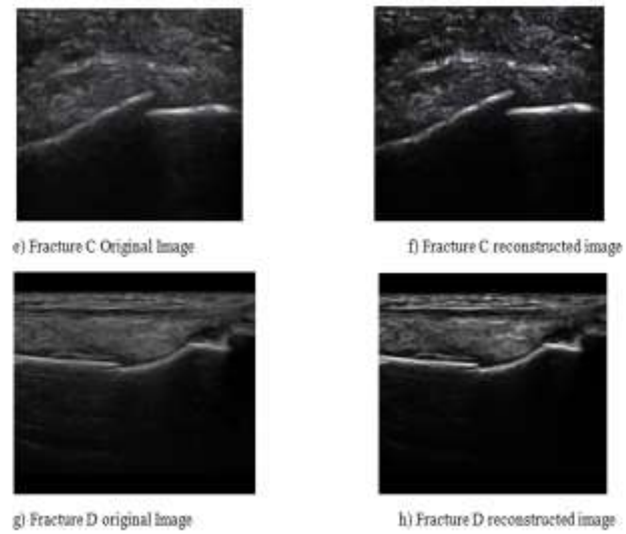

Figure 3: Fractures C and D before and after reconstruction.

The values of the Peak Signal to Noise Ratio, mean and variance are shown in the tables below

Table 1: Shows the Peak Signal to Noise Ratio (PSNR) for the images.

Feature	Image	Fracture A(dB)	Fracture B(dB)	Fracture C(dB)	Fracture D(dB)
PSNR	Original	43.14	42.33	35.78	40.23
	Reconstructed	45.19	44.19	38.95	42.78

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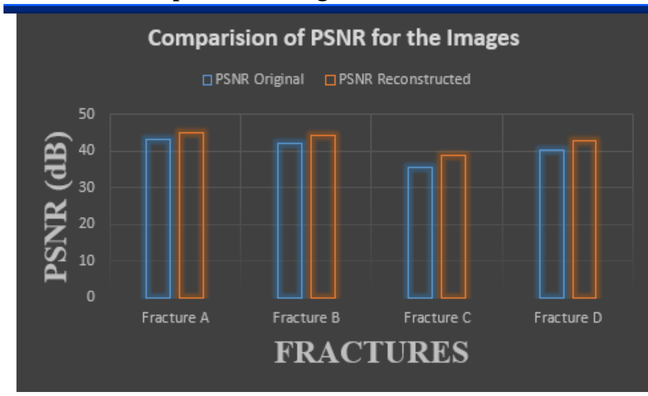

Figure 4: Shows a comparison of PSNR for Fractures A, B, C and D

Table 2: Mean and Variance values of Fracture A, B, C and D image.

Feature	Images	Fracture A	Fracture B	Fracture C	Fracture D
Mean	Reconstructed	85.5	84.5	86.9	80.9
	Original	79.6	77.5	78.9	79.4
Variance	Reconstructed	565	562	559	566
	Original	678	675	677	672

4. CONCLUSION

From the analysis of the results it can be observed that the images reconstructed using the migration method in MATLAB have slightly higher Peak Signal to Noise Ratio(PSNR) as compared to the images produced by the conventional ultrasound machine. Increase in the PSNR indicates that the migration method implemented in the post-processing of the images improved the quality of the images. The images were also compared in terms of mean values and variance. The improvement of the mean values indicate that the dynamic range of intensity values is modified uniformly by balancing the illumination and reflectance components of each image. An increase in the mean gives the contribution of individual pixel intensity for the entire image, while an increase in variance is directly linked to the variation in pixel values, which increases the amount of noise in the image.

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