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ANALYSIS OF WAVELET ALGORITHM TECHNIQUES EZW, SPIHT, STW & WDR IN ULTRASOUND MEDICAL IMAGE COMPRESSION

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ABSTRACT:

Medical Ultrasound is essential diagnostic tools for women health comparing with other modalities. As it is non-radiated, harmless to human organs it is globally accepted as a periodical procedure for obestritics and gynecology healthcare. The research opportunities in ultrasound image enhanced applications area are plenty, similarly compression algorithms for medical images such as CT and MRI are processed by the same algorithm, so this paper is aimed at using the best compression algorithm for the compression of especially ultrasound images. To analyse and evaluate the effectiveness of wavelet based embedded zerotree wavelet, set partioning in hierarchical tree, wavelet difference reduction, spatial orientation tree wavelet compression for ultrasound images. A comparative study based on the performance parameters such as peak signal to noise ratio (PSNR), compression ratio (CR), bits per pixel (BPP) and mean square error (MSE). The best algorithm for the ultrasound image compression among the above methodologies is studied

in detail and is implemented by using best tool.

KEYWORDS:-

Embedded Zerotree Wavelet (EZW), Set Partioning In Hierarchical Tree (SPIHT), Wavelet Difference Reduction (WDR), Spatial Orientation Tree Wavelet Compression (STW), Peak Signal To Noise Ratio (PSNR), Compression Ratio (CR), Bits Per Pixel (BPP) and Mean Square Error (MSE).

INTRODUCTION:

In digital image compression, image enhancement is based upon image compression and reconstruction of image with certain parameters related to human perception. This paper is mainly focusing on ultrasound image compression using specific algorithm. Ultrasound image compression is mainly used instead of CT and MRI since the viewing pattern of the diagnostic organ varies. The ultrasound images can be viewed small parts of organs, cross sectional view, para-sternum, apical and sub-costal positions. The ultrasound has the ability to view the targeted structure and visualize it in real time just by adjusting the needle or probe position. The technique is portable, less expensive and the exposure to radiation does not harm much. Ultrasound are used for visualizing muscles, tendons, internal organs, to determine size, structure, lesions and abnormalities. Generally ultrasound uses high frequency probes (10-15 MHZ) than low frequency (5-10 MHZ) because it provides better resolution and less penetration.

There are a lot of compression algorithms for medical images but the same algorithm cannot be used to compress images of different modalities. Since the picture resolution varies for different images. The medical images should be preserved for a long period of time i.e., 15-20 years so they used PACS (Picture Archiving Communication System) for storing it. These PACS will consist of periodical patient data and images, the images need effective compression algorithm.

Objective of this paper is the ultrasound medical images shall be transmitted very easily without affect the originality of the image. This is possible only if the proper image compression algorithm is used to compress, store and retain the image. The

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ultrasound image compression should posses the following.

i) he distinction of errors in the compressed ultrasound image depends upon the location of original image.

ii) he compressed ultrasound image should be exact depiction of original image and should have same information as that of original image.

iii) he ultrasound image is compressed with the following wavelet based compression algorithms and the best algorithm and tools are analysed in terms of performance comparison.

COMPRESSION ALGORITHM:

lossy and lossless compression standards are used in medical images based on ROI and Non-ROI image regions. Compression of ultrasound images has many transformations. The FT, DTFT transforms were obsolete as it does not contain any internal information of source data, but the wavelet based image compression is used with additional features such as compactness, easy process and robustness. The wavelet based compression algorithms produce very low bit error rate for given compression ratio and have good image quality.

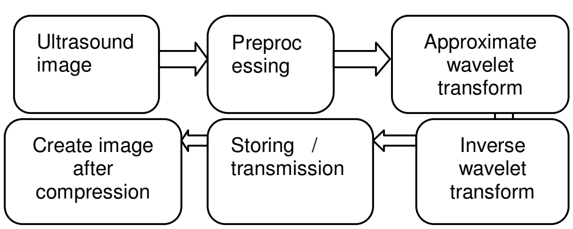

Fig 1.Compression steps

There are many wavelet compression algorithms being applied for specific applications, one among the best is analysed here for ultrasound image compression with various parameters.

1.EZW (Embedded Zerotree Wavelet):

EZW algorithm can be used in ultrasound image processing to show the full power of wavelet based image compression and stream of one dimensional ultrasound scan data. It is a process of encoding the magnitude bit stream transform in a progressive manner. It allows concise encoding of significant values position. EZW uses embedding process called bit–plane encoding. This bit plane encoding is continued till the quantized transform magnitude is obtained which is close as the desired transform magnitude. The sign and bits during decoding can be used to construct any degree of accuracy else compression ratio is desired and is performed till the number of bits gets exhausted. EZW coding technique provides multi resolution wavelets with high quality image.

The bit plane encoding consists of binary expansion T_0 as unit for transform values and recorded in magnitude as significant bits. The first significant bit is always 1 if not encoded the sign is encoded first. This coherent ordering of encoding the highest magnitude bits are encoded first and this allows for progressive transmission .The wavelet transform is well suited for bit-plane encoding because the image have few magnitude values i.e., found in high level sub bands. Initially the magnitude values are approximated to produce low resolution but it is a recognizable portion of the image.The low magnitude values are encoded to high magnitude values of the refined details of image.

The Embedded Zero tree encoding is incredibly implicit, computationally compact and the position of significant values description is got by the position of insignificant values. These insignificant values are organized by zero tree. The zero tree is defined as the quad tree-a tree with wavelet transform with a root [i.j] and its children [2i,2j],[2i+1,2j],[2i,2j+1],[2i+1,2j+1] and each of their children and so on . Zero trees are useful only if they occur frequently. The EZW works by replacing the significant values by bit-plane encoding procedure.

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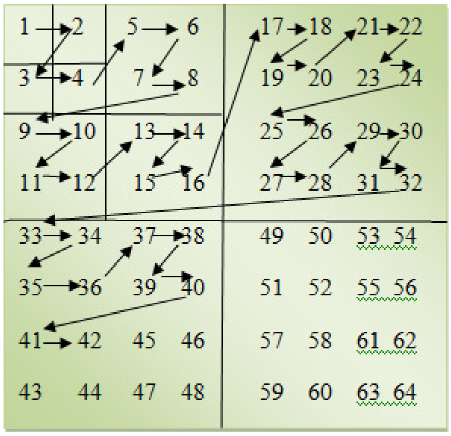

Fig 2.Scanning order of EZW

2. SPIHT (Set Partioning In Hierarchical Trees)
Set Partioning In Hierarchical Trees is a wavelet based image compression algorithm.In SPIHT initially the image is converted into its wavelet transform and then information is transmitted about the wavelet co-efficient, SPIHT is a highly refined version of EZW algorithm and it operates on an entire image at once.It obtains high PSNR values for a given compression ratio.It is most widely used image compression algorithm.The coding and decoding of the images is faster than EZW and provide better error protection. The SPIHT produce high quality image and uses simple quantization algorithm.
The term Hierarchical trees refers to quadtree as discussed in EZW.Set partioning refers to the position of quadtrees of wavelet transform values at a given threshold.By careful analysis of these transform values Said and Pearlman were able to improve EZW. The SPIHT coding uses three lists , two passes called sorting and refinement pass. The three lists contain location of the co-efficients along with their co-ordinates.

1) ist of significant pixels (LSP)
2) ist of insignificant pixels (LIP)
3) ist of insignificant sets (LIS)

SPIHT perform recursive partioning which allows in identifying the position of significant co-efficient in descendants of considered co-efficient. During sorting the co-efficients in insignificant pixels are sorted and the threshold whose significant values are moved to list of significant pixels.The spiht algorithm is coded in hierarchical steucture in a tree based quantization of co-fficients.These transformed co-efficients are ordered partially and they are recalculated by decoder.The co-efficient values of refinement bits are ordered in bit plane transmission.SPIHT is suitable for telemedicine because it uses embedded coding with progressive transmission and this is a major advantage of it.The ordering of co-efficients is from maximum to minimum which makes compression energy efficient. SPIHT algorithm has fast coding time ,precise rate control,can be used for lossless compression and can code to exact bit rate.

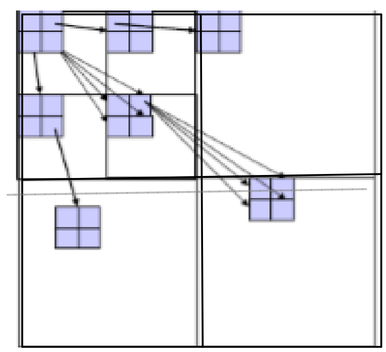
Fig 3. SPIHT scanning order

3.STW (Spatial Orientation Tree Wavelet):
STW is Spatial Orientation Tree Wavelet is a modified form of SPIHT algorithm .STW technique is based on the partioning of wavelet and by keeping the insignificant co-efficients together in larger subsets. It uses spatial relationship between the wavelet co-efficients.
A Spatial Orientation Tree is defined as the tree structured set of co-efficients with the tree root started at one of directional bands at any level. The three direct descendants of any LL band co-efficients are the tree roots of three full depth spatial orientation trees.The three trees carry the high frequency information in three different orientations horizontal,vertical and diagonal of corresponding spatial region.If tree root starts at

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highest level directional bandsit is depth spatial orientation.
The STW performance is based on three concepts partial ordering of transformed image by magnitude,transmission of co ordinates via a set partioning algorithm and exploitation of the hierarchical structure in subband transformation.STW is essentially SPIHT algorithm and only difference is that in organzing the output coding .SPIHT is easily explained by underlying the concepts of STW.It uses a state transistion model for encoding the information.The location of transform values undergo state transisitions.This allows STW to reduce the number of bits needed for encoding.

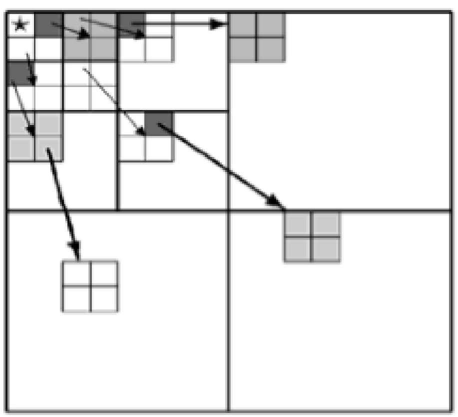

Fig 4. Scanning order of STW

4. WDR (Wavelet Difference Reduction):
WDR is a wavelet based image compression developed by James S.Walker .One defect of SPIHT is that it only locates the position of significant co-efficients which makes the operation difficult for exact transform values position .So to overcome this WDR uses region selection called Region Of Interest.In this only a portion which requires high resolution is selected and the transformation is done.WDR do not produce high PSNR values than SPIHT but produce high quality images at high compression ratio.
In WDR,the indices of significant values is not considered instead the successive difference between the indices is taken.Then binary expansion of the indices difference is done.Then the most significant for these will be 1 so it can be dropped and signs are used as seperators in the stream.WDR replaces the significant pass in the bit plane encoding.

PERFORMANCE PARAMATERS:
The ultrasound image compression is analysed based on the below parameters such as PSNR,MSE,CR and BPP.

PSNR:
PSNR is Peak Signal to Noise Ratio .It is used to measure the quality of reconstructed image.For higher PSNR values it produces superior quality images. PSNR cannot be used to compare the quality of two different images.
PSNR=10 log $(2^n-1)^2$/MSE
Where n is the pixels and MSE is Mean Square Error.
MSE:
MSE is Mean Square Error .It is a measure of image quality index or it is the difference between original and reconstructed image.
MSE=$1/MN \sum_{i=1}^{M} \sum_{j=1}^{N} [p(i,j)-p'(I,j)]^2$
Where p(i,j) is original data and p'(i,j) is the noise produced due to compression.Lower the value of MSE the image is of better quality.
CR:
CR is Compression Ratio.It is the ratio between the number of bits required to represent an image before compression to the number of bits required to represent an image after compression.
CR=Image before compression/Image after compression

BPP:
BPP is Bits Per Pixel. It is the number of distinct colour for given pixel.for 1-bit per pixel it can either be on or off.For 2-bpp it has 4 colours.For 3-bpp it has 8 colours.

1 bpp,2^1=2 colours
2 bpp,2^2=4 colours
3 bpp,2^3=8 colours

CONCLUSION:

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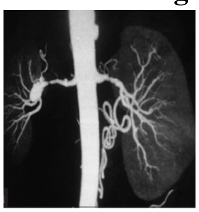
There are few of general graphs for the compression of images using Embedded Zerotree Wavelet, Set Partioning In Hierarchical Trees, Spatial Orientation Tree Wavelet, Wavelength Difference Reduction. The compression of normal and ultrasounds images vary because they differ in the pixel resolution, quality of the image, rate of compression time.

Medical Image Inputs:



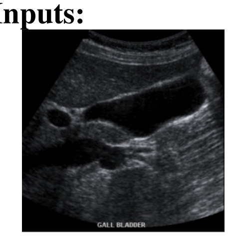


Fig 5 & 6. CT kidney image tagged as 1.Jpg and US Gallbladder image tagged as 2.Jpg.

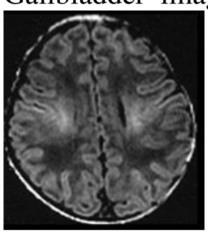


Fig 6 & 7. MRI brain image tagged as 3.Jpg and X ray extremity image tagged as 4.Jpg.

Fig 8. Mammogram image tagged as 5.Jpg

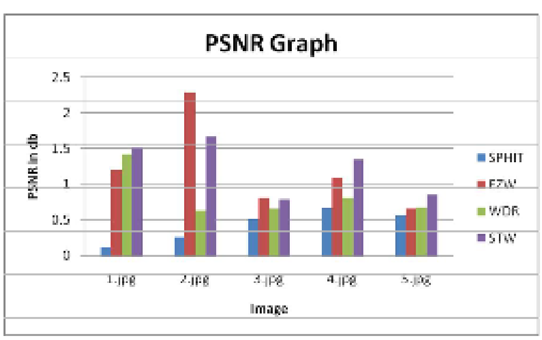


FIG 5. PSNR graph for different compression methods.

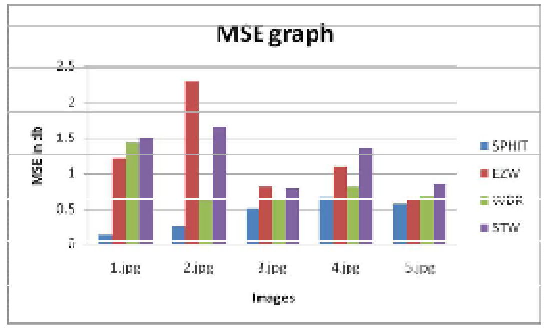


FIG 6. MSE graph for different compression methods.

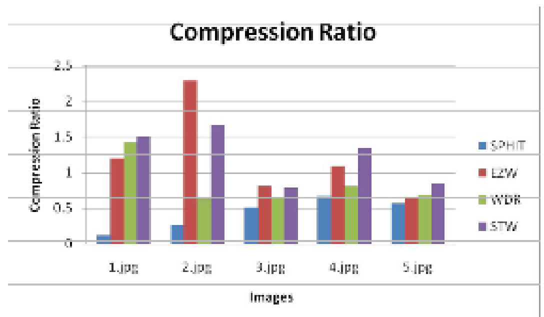


FIG 7. CR graph for different compression methods.

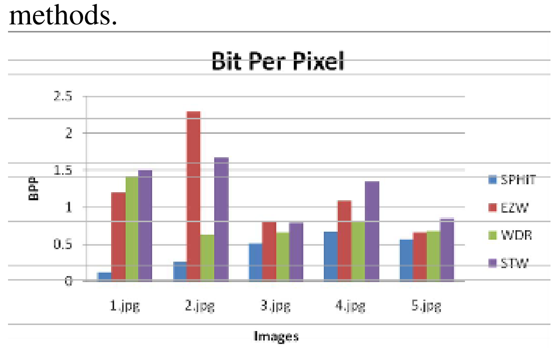


FIG 8. BPP graph for different compression methods.

These are the different paramaters for analyzing the best compression algorithm of images and in the same way the ultrasound image is being analysed for the same parameters by using the required software tools.

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