Denoising and wavelet compression of X-ray image for teleradiology

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Abstract: The Teleradiology solution is the provision of medical care over long distances by way of videoconferencing and other communication technologies to best consultancy for diagnosis. For teleradiology, image size & noise improvement is challenging research topic. Mostly X- ray images are often corrupted by noise due to a noisy channel or faulty image acquisition device. In this paper proposing median filter methods are used for denoising and wavelet based compression is implementated for transmission. The wavelet based method used in this paper is Set Partitioning in Hierarchical Trees Algorithm (SPIHT) which is a type of Multiwavelet transforms. The image quality of the system has been evaluated based on compression ratio, peak signal to noise ratio and entropy.

Keywords: X-ray; teleradiology; Denoising; wavelet; SPIHT.

I. Introduction

Teleradiology is a useful tool for doctors, with the help of this technology at the time of emergency incidents doctors concern the second opinion during the confrontation. Doctors can exchange and store medical images as well as other medical information for remote consultations with fast and secure low cost medium called telemedicine and teleradiology system [1]. For that efficient method is required for transmission of image & information. So efficiently noise reduction from medical image data is a challenging task for image processing technique. For noise reduction mostly filter technique are used. Most of the convectional noise filter produces undesirable distortions and blurring effects during noise removal process.

The physiological signals and medical images will suffer from noise generated by the equipment in the acquisition phase and noise generated by the external sources and transmission medium while transmitting from one place to another place as part of Telemedicine and Teleradiology. So the development of image denoising techniques became an active research area at present [2]. The requirement to get rid of noise is very necessary before transmitting the image. The traditional method to take away impulse noise as well as speckle is by windowing the noisy image with a standard median filter [3]. The median filter has ability to reduce impulse noise without blurring the edges of X-ray image.

The most common feature of teleradiology is the ability to transmit high quality of image. It is necessary to compress the medical images for transmission & storing the huge data base of images in hospitals. In compression technique many lossless and lossy compression algorithms are available. In recent years, discrete wavelets transform (DWT) coding have been actively used by researcher for image compression. Mainly DWT has multi-resolution character and superior energy compaction. It also alleviates the blocking artifacts due to the overlapping nature of the transform. So significant improvement in image quality at higher compression ratios is getting with Wavelet-based coding. Wavelet-based schemes [4] are powerful and sophisticated method for image compression. But scalar wavelets have implementation constraints so it is not satisfy all these properties simultaneously. So new class of wavelets those have more than one scaling filter is used those called 'Multiwavelets' [5]. The possibility of perform are superior to scalar wavelet with similar computational time. Quantization and coefficients of embedded coding has been used for evaluating the effectiveness of the Multiwavelet transform for coding images or videos at low bit rates. When embedded coding is applied to transform image the advantage of the decor relation properties of its coefficients has been realized. Commonly used embedded coding schemes are embedded image coding using zero trees of Wavelet coefficients (EZW) and Set Partitioning in Hierarchical Trees Algorithm (SPIHT).

The purpose of this paper is to derive a method which reduced the noise and compressed the x ray image with appropriate rate without losing the

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medical information from the image for teleradiology. The SPIHT coder is efficient image compression algorithm which works on various bit rates and reconstructed images can be obtained from an embedded bit stream. This algorithm gives the high quality image with high PSNR without losing the information of the image. This proposed algorithm robustly improves the visual quality of the image at all the bit rates.

The rest of the paper is organized as follows. Section II explains the existing methodology in this domain. Section III describes the proposed methodology. Next section IV shows the experimental results obtained. Section V explains

II. Existing Methodology

Now a day, critical role is played by image compression in Telemetric applications and especially in telemedicine & Teleradioalogy. To transmit the images over computer networks, either a single image or sequence of images, so they can be used in multi medical purposes. This is very much required so that many medical images can be reliably transmitted so that fast medical diagnosis is facilitated. To achieve this transmission of multi images in one go, image compression becomes important issue. We have to be concerned with the only fact that higher compression rates can be achieved with the only condition that reconstructed images should not lose any information and important characteristics should be preserved.

The compression methods should be able to preserve all the important image information needed for diagnosis. Here comes the Lossy and Lossless image compression technique into picture. Lossy techniques are not able to preserve the image information where as lossless do. Therefore we are using DWT based compression technique so that image can be reconstructed well after compression.

The existing methods of image compression like Discrete cosine transform have been replaced by Discrete wavelet transform based compression method as these methods have high accuracy, low memory requirements and accurate image reconstruction. The proposed methodology SPIHT is a placement for wavelet compression methods [6]. In the existing techniques, image denoising was not taken into account due to which compressed images were usually corrupted with transmission noise. In our proposed methodology, the image is denoised first using a median filter of suitable kernel and compression is achieved with better accuracy which we have analyzed in terms of PSNR and entropy.

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III. Proposed Methodology

A. Image De Noising using median filter

The median filtering method used to remove noise from images. It is widely used filter in image enhancement as it is very effective in removing noise at the same time preserves edges from getting blurred. It is particularly effective at removing ‘salt and pepper’ type noise as well as speckle noise. The median filter works by replacing each value with the median value of neighboring pixels [7]. The median filter can work on any window size and in our case 3x3 has given good results.

The median is calculated by first sorting all the pixel values either in increasing or decreasing order and then replacing the pixel being considered with the middle (median) pixel value. In medical image enhancement, noise reduction has great significance before performing higher level processing steps. In a noisy medical image, these noisy pixels are replaced by new pixel values which are introduced using median filter. The best result achieved in this paper is median filter of 3x3 window size.

B. Discrete Wavelet transform and SPIHT

The Discrete wavelet transform (DWT) is a linear compression and transformation method that operates on a given set of pixels of image in the form of a vector and transforms it into different sub vectors of the same length. The length of DWT is in an integer power of two. Different frequency components can be separates in data by mathematical tool and resolution of each component is matched to its scale [8]. DWT is computed with a cascade of filters either down sampled or up sampled by a factor 2 as shown in figure.1

The figure 1 shows the DWT tree which is computed by filter banks of different frequencies constructed using a combination of low pass and high pass filters.

The wavelet transformation is very effective tool for achieving compression. Sub band filtering system is identical in wavelet transform technique [9]. Based on frequency an image is first decomposed into four parts by sub sampling horizontal and vertical channels using sub band filters.

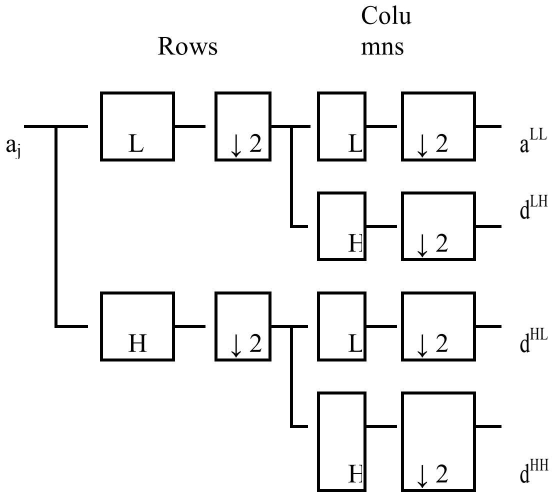

Fig.1. DWT tree

Low (HL) and High-High (HH) sub bands as shown in Fig.2.

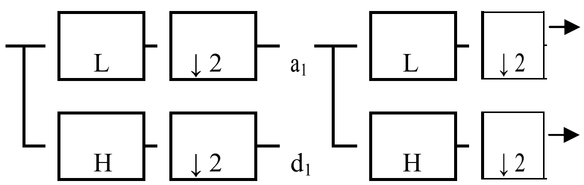

Fig. 2 Wavelet algorithm for level 2 decomposition

After applying wavelet transform to a 2-D image, the SPIHT algorithm (*Set Partitioning in Hierarchical Trees Algorithm*) partitions the decomposition into four sub bands which can be significant or insignificant contributions in the image [10].

In this paper, we have done the decomposition up to two levels. The sub-bands obtained for two-level decomposition are shown in Fig.3 The sub-band coefficients obtained from four sub band filters. The coefficients in each spatial orientation tree are the coded from the most significant bit-planes (MSB) to the least significant bit-planes (LSB). The list of insignificant pixels and insignificant sets are denoted as LIP and LIS whose magnitudes are smaller and greater than threshold values.

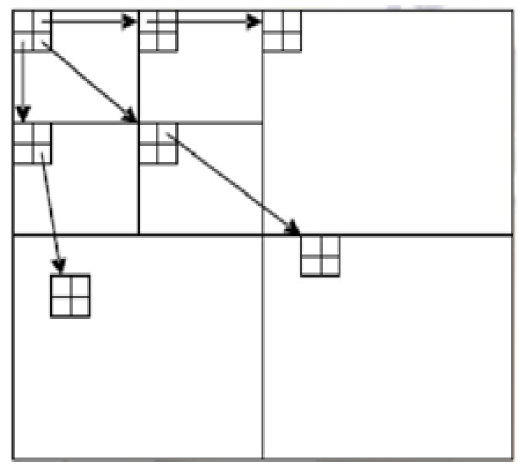

Fig.3 Two-level SPIHT decomposition

SPIHT provides higher PSNR and compression ratio than DWT because of its property that indicates significance of child nodes of a significant parent node without any conflict.

IV. Experimental Results

For teleradiology the denoised image generated by median filter has to be compressed for transmission. The compression of the medical image is achieved by implementing wavelet transform and SPIHT algorithm. The experiments were performed on the several X-ray images of knee and results are shown for one of the knee X-ray image. Fig 5 shows the original X-ray image of knee.

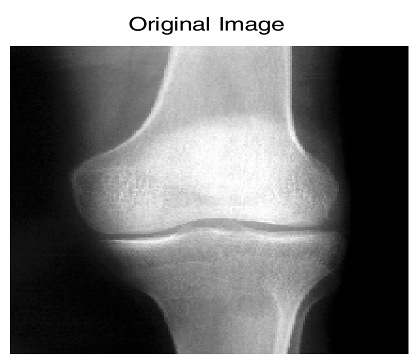

Fig. 5 Original X-ray Image of Knee

Now, on this original image, a 3 x 3 median filter is applied to denoise the image from salt and pepper noise. Fig. 6 shows the denoised image generated by median filter.

median filtered image

Fig. 6 Denoised Image generated from median Filter

Now, for transmission of images via wired or wireless channels the wavelet transform followed by SPIHT is performed. For wavelet transform the rate of compression is chosen by the user. The results are verified by the means of PSNR and entropy of the images. Table I shows the PSNR, entropy and compression ratio (CR) of the reconstructed or compressed image with the variation of rate of compression (between 0 and 1).

Table I : PSNR and entropy of image at different rate of compression

S.No	Rate of Compression	PSNR	Entropy	CR (%)
1.	0.1	34.2570	0.0018	90
2.	0.2	34.4837	0.1793	80
3.	0.3	34.5155	0.1236	70
4.	0.4	34.5192	0.0949	60
5.	0.5	34.5199	0.0772	50
6.	0.6	34.5199	0.0653	40
7.	0.7	34.5199	0.0566	30
8.	0.8	34.5199	0.0500	20
9.	0.9	34.5199	0.0499	10
10.	1.0	34.5199	0.0407	0

It is observed from the above table that at the rate of 0.5, the best results are obtained with highest PSNR value of 34.5199 and acceptable entropy of 0.0772 and with optimum compression ratio of 50%. Fig. 7 shows the reconstructed image at rate of 0.5.

Reconstructed Image

Fig. 7 Reconstructed Image with rate of 0.5

From the above discussion it is clear that for teleradiology the proposed scheme of denoising followed by compression gives encouraging results.

V. Conclusion

In this paper, denoising is done by median filter and for compression SPIHT wavelet method is used. This work gives encouraging results with rate of 0.5, high PSNR 34.5199 and low entropy 0.0772 and optimum compression ratio of 50% achieved. The scope of this work can be extended to other variant of medical images as well as different wavelet noise reduction techniques can be implemented to get better results.

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