IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661, p- ISSN: 2278-8727Volume 15, Issue 3 (Nov. - Dec. 2013), PP 01-07
www.iosrjournals.org

A Comprehensive lossless modified compression in medical application on DICOM CT images

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ABSTRACT : *In current days, Digital Imaging and Communication in Medicine (DICOM) is widely used for viewing medical images from different modalities, distribution and storage. Image processing can be processed by photographic, optical and electronic means, because digital methods are precise, fast and flexible, image processing using digital computers are the most common method. Image Processing can extract information, modify pictures to improves and change their structure (image editing, composition and image compression etc.). Image compression is the major entities of storage system and communication which is capable of crippling disadvantages of data transmission and image storage and also capable of reducing the data redundancy. Medical images are require to stored for future reference of the patients and their hospital findings hence, the medical image need to undergo the process of compression before storing it. Medical images are much important in the field of medicine, all these Medical image compression is necessary for huge database storage in Medical Centre and medical data transfer for the purpose of diagnosis. Presently Discrete cosine transforms (DCT), Run Length Encoding Lossless compression technique, Wavelet transforms (DWT), are the most usefully and wider accepted approach for the purpose of compression. On basis of based on discrete wavelet transform we present a new DICOM based lossless image compression method. In the proposed method, each DICOM image stored in the data set is compressed on the basis of vertically, horizontally and diagonally compression. We analyze the results from our study of all the DICOM images in the data set using two quality measures namely PSNR and RMSE. The performance and comparison was made over each images stored in the set of data set of DICOM images. This work is presenting the performance comparison between input images (without compression) and after compression results for each images in the data set using DWT method. Further the performance of DWT method with HAAR process is compared with 2D-DWT method using the quality metrics of PSNR & RMSE. The performance of these methods for image compression has been simulated using MATLAB.*
Keywords: *JPEG, DCT, DWT, SPIHT, DICOM, VQ, Lossless Compression, Wavelet Transform, image Compression, PSNR, RMSE.*

I. INTRODUCTION

In term preserving a soaring visual quality standard of decompressed image, the main motive of image compression is to achieve a very squat but rate representation. Compression reduces the storage and finds its potency and limitation. Without losing its entropy significantly compression transmits burden of raw information by reducing the ubiquitous redundancy [4]. Two techniques exit for compression to find out, first is lossy technique (in this some of data may be lost or some identified loss or changes may incurred). Second in lossless technique, in this technique the reconstructed images exactly same as the original. In multimedia and digital image compression is considered as an essential technology in providing better result. The challenge is to obtain high compression ration without the loss of image communication field [5]. By using specialized software, which will be described in more detail late in the article, DICOM images can be compressed by converting the data into smaller image file [10]. As compression technique are very helpful in mass storage and transmission, many lossless techniques are used like Discrete Wavelet transform, Huffman coding and run length encoding, arithmetic coding are quality or diagnostic accuracy. The underline ides behind most of the lossy compression algorithm is to transform the image and to project it on an orthogonal function basis in order to distribute the energy of the signal among these de-correlated components. The progress of the theory of multi resolution decomposition has allowed the application of compact coding of Wavelet image representation and these representations diverge in the preference of the wavelet. The principle behind the Wavelet transform is to decompose an original signal into a series of low resolution signal associated with the detailed signal. It contains all the necessary information that is required to rebuild the signal at each resolution level and at the next higher level [1][9]. In DICOM format all the information about the image is contained in the header is the image modality and information about the patient. Over and above this field in the header which defines that " Transfer

Syntax Unique Identification" that relates to the type of compression applied to the image data. The image data then follows the header. Currently, DICOM standards supports run- length coding (RLE), lossy JPEG, lossless and JPEG 2000 for compression of the image data [Ramakrishnan]. In this paper, by using DWT method through HAAR process DICOM images can be compressed. Discrete Wavelet Transform (DWT) is a proficient tool for multi- resolution sub band decomposition of signals useful numerous signal and image processing applications, without great loss of visual quality than the previous technique such as the Discrete Cosine Technique (DCT) and the Discrete Fourier Transform (DFT) [6]. Wavelet transform divides the information of an image into approximation and detail sub signals. The approximation sub signal shows the general trend of pixel values and other three detail sub signals show the vertical, horizontal and diagonal details or changes in the images [8].

II. RELATED WORK

Ramakrishnan et al. (2006) proposed a methodology for compression of DICOM images based on wavelets and splint for telemedicine applications. In this paper they proposed a method for compressing DICOM images for different entities on well known set partitioning in hierarchical trees (SPIHT) SPIHT having the progressive transmission capabilities which is quiet useful for telemedicine application in which DICOM image header is transmitted first and then progressively followed by image details transmission in various stages. SPIHT produces embedded bit streams of the image and works on the principle of spatial relationship among the wavelet co-efficient at different levels and frequency sub-bands in the pyramid structure of wavelet decomposition. They compare their results on PSNR, MSSIM metrics for different compression scheme like JPEG-200, JPEGCS, JPEG to the propose scheme (SPIHT). Finally, they concluded that SPIHT gives better result as compare to other scheme by consuming less bandwidth and saving time [11].

Kumar et al. (2008) proposed a mechanism for performance of image compression techniques Using DCT (Discrete Cosine transform), SVD (Singular Value Decomposition), BTC (Block Truncation Code), STD (Standard Deviation) methods depending upon the image properties and requirements. In this paper, the two main compression techniques SVD and BTC associated to DCT in JPEG baseline coding to find its potential and limitation of data redundancies. The advantages of SVD were due to the property of energy compaction and ability to adapt the local statistical variation of an image. Moreover, BTC generally preserves the first and second moments of movements of each block. Finally, they concluded that the obtained results of the proposed work clearly depicts that the incorporation of SVD and BTC in age compression along with DCT was in an adaptive manners which enhanced the compression performance significantly. The proposed work result was quiet reliable in terms of PSNR and MSE [4].

Bairagi et al. (2009) proposed a methodology for selection of wavelets for medical image compression. They mainly worked over various wavelets transform methods to analyze DICOM CT image over several metrics like MSE (Mean Square Error), PSNR (Peak Signal Noise Ratio), Structural contents, Normalized Absolute Error etc. Moreover, they found out quality of measure for different wavelet type on DICOM CT images. They read the some of the limitation of SPIHT techniques in which there was no specification for particular wavelets type used as image compression. Furthermore, they had done analysis over all the 'db' wavelet series and compare their results over several metrics. In this paper, comparison and analysis was made over the class of wavelets like orthogonal and bi-orthogonal and the author concluded that the bi-orthogonal 4.4 wavelet was most suitable for medical image compression application [1].

Dhawan et al. (2011) reviewed and discussed about the image compression, need of image compression, its principles, classes and various algorithm of image compression. They mainly worked over gray scale images of Lena and finger print images. The author discussed over various compression algorithms based upon wavelet, JPEG/DCT, VQ, fractal and compare their results on the basis of PSNR values and CPU time over encoding and decoding. Finally, the author concluded that the wavelet based compression algorithms are strongly recommended. Discrete cosine transform should use an adaptive quantization table. VQ approach is not appropriate for a low bit rate compression and fractal approach should utilize its resolution-free decoding property for a low bit rate compression [7].

Morales et al. (2012) presented a method for finger print verification by correlation using wavelet compression of pre-processing digital images. In this paper, they implemented a practical digital security system that combines digital correlation, wavelet compression with digital images pre-processing. The proposed work had been implemented a biometric system that used as pattern the recognition of digital fingerprint which satisfied the characteristics of uniqueness, universally, performance and collectability. The biometric fingerprint system mainly contains two inputs that were passwords and fingerprints. The fingerprint was captured by the biometric sensor "APCBIOPOD", then the image was pre-processed took skeleton itself and stored in a database for making the comparison and to authenticate the user. The author used specific Fourier transform and wavelet transform to perform the function using correlation, compression, compressed filter, transformation and finally user interface implementation [3].

Dubey et al. (2012) presented a new JPEG 2000 based lossy image compression method based on 2D discrete wavelet transform. They mainly worked over 3D medical image compression using Huffman encoding technique. In the proposed method, 3D image was divided into smaller non-overlapping tiles on which 2D DWT was applied and after that hard thresholding and Huffman coding were applied on each of the tiles to get compressed image. Moreover, the author explained that the performance of the proposed work of 3D JPEG 2000 image compression algorithm was measured over various images and concluded that the proposed algorithm had better performance than JPEG compression in low and high bit rates [2].

III. PROPOSED WORK

In proposed method, a advanced approach to image compression technique is used that upgrade or improve its performance ,minimum data loss and also reconstructed that image, which is known as Discrete wavelet transform in dcm. We are using lossless compression technique, one of the method used is HAAR process. This process is a sequence of square shaped function that further forms wavelet and this wavelet is based on Fourier Transform. HAAR uses orthogonal combination on unit interval. The technical, directional and anatomical aspects of an image are compressed using wavelets transformation of HAAR process. HAAR Wavelet decomposition is one of the best methods of decomposition of images.
Development of Discrete Wavelet Coding Algorithm

1. Development of a representative data set of DICOM CT images.
2. Study of various linguistic Image Compression Techniques.
3. Select an input image from the set of data set.
4. Development of a storage schema which maps the discrete wavelets Transformation techniques for image compression using HAAR process.
5. Development of an interface for storing the step wise procedure of compression for wavelet transformation.
6. Analyze the results for approximation A1 with respect to input image for metrics like RMSE, PSNR. Metrics like RMSE, PSNR.
7. Rescheduling the image compression procedure after approximation A1
8. Analyze the results for approximation A2 with respect to input image for requisite metrics.
9. Save the some sort of information of input images as according to their modality in the dataset. Results analysis and comparison for all the inputs in the dataset.
10. Performance of DWT method with HAAR process is compared with 2D-DWT method using the quality metrics of PSNR & RMSE.

IV. RESULTS AND DISCUSSION

HAAR Wavelet approximation is one of the best methods of discrete images. For input, approximated images is passed to the HAAR process to compress and this process measure the best in compression for the DICOM CT images. The input images can be the set of images from data set can be brain image then analyze the result for approximation 1 and approximation 2 with respect to input images. The performance of compression images is measured by PSNR and RMSE. MATLAB gives graphics tools and reference-standard algorithms for image processing, analysis, to examine a region of pixels, to detect and measure features, and analyze shapes and textures, visualization, and algorithm development. HAAR is proved to be best as compared to the other processes. Original image formatted in DICOM format of size 256×256 with 8 bit resolution is input to software. The 'Compressed image' is the image which is generated at the decoder side after reconstruction process. This shows that our HAAR process gives better results. The Haar transform is the simplest of the wavelet transforms. This transform cross-multiplies a function against the Haar wavelet with various shifts and stretches, like the Fourier transform cross-multiplies a function against a sine wave with two phases and many stretches. Evaluation of performance of any medical DICOM CT images can be made by the parameters such as RMSE and PSNR. Root-mean-square error (RMSE) is a frequently used measure of the differences between values predicted by a model or an estimator and the values actually observed.

$$RMSD = \sqrt{\frac{\sum_{t=1}^{n}(y_t - \hat{y}_t)^2}{n}}$$

PSNR is generally used to analyze quality of image, sound and video files in dB (decibels). In other words, *PSNR is* to measure the quality of reconstructed images that have been compressed.

$$MSE = \frac{1}{m\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

Where, MSE represents the squared error of the images defined as,

$$PSNR = 10.\log_{10}\frac{(MAX_1^2)}{MSE}$$
$$= 20.\log_{10}\left(\frac{MAX_1}{\sqrt{MSE}}\right)$$
$$= 20.\log_{10}(MAX_1) - 10.\log_{10}(MSE)$$

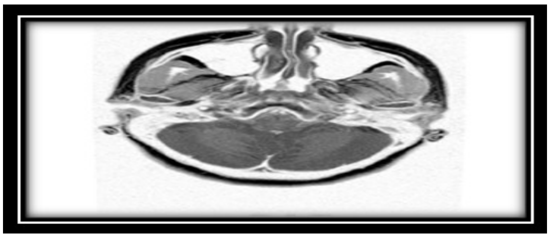

Figure 1: Input DICOM brain image at client side

The above image is the input image which is undertaken for the simulation and after which we may proceed for further compression process to be carry out. This is the very first result of input image at client end.

Figure 2: Converting input image into gray scale

The figure depicts the very first step of image compression in which we first convert the taken input image into gray scale and other more properties like size and image contrast for poor and adjusted terms of nature of the image. This is the basic step of compression of image which is performed according to the need and performing nature of implementation of the requisite process.

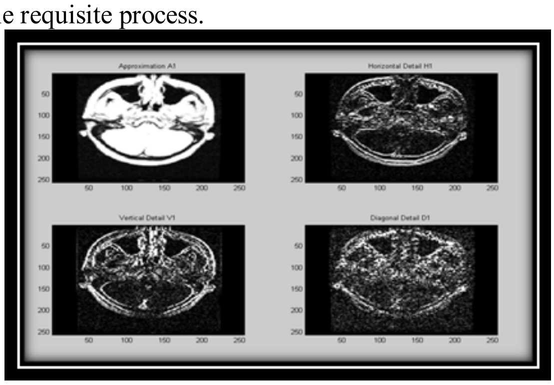

Figure 3: Results for input image after Approximation A1 (decomposition level first)

The figure signifies the result of first level decomposition of image by approximation $A1$. In this step, we find the results of compression according to their Horizontal detail compression termed as $H1$, vertical detail compression termed as $V1$ and diagonal detail compression termed as $D1$. From the analysis of above figure 5.5 we found that there is

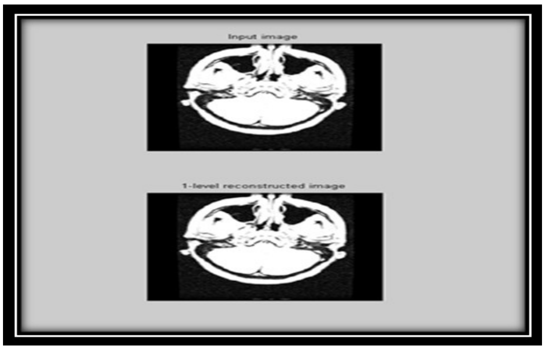

Figure 4: Decomposition level-1 reconstructed image

The figure depicts the results of reconstructed image after first level decomposition in which we carry out compression of image diagonally, vertically and horizontal. For the sake of further compression at that time, it must require to reconstruct the image by applying inverse mechanism. From the results of reconstructed 1-level decomposition level we may now in position to do further decomposition of the input image.

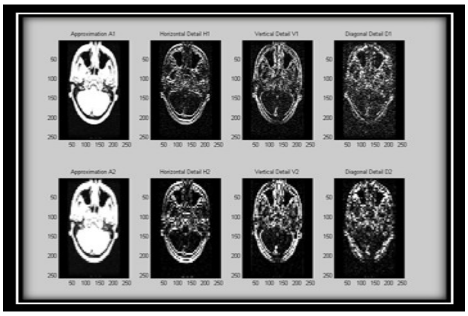

Figure 5: Comparison snap shot for both level of decomposition of the image

The figure depicts the comparison analysis for both level of decomposition namely approximation A1 and approximation A2.The result signifies that the two level decomposition results are quiet good and vulnerable as compare to decomposition level-1. The results analysis and comparison is totally based over wavelet transform for the proposed process on different coefficients and labels. Furthermore, the evaluated results made comparison over the analysis of horizontal, vertical and diagonal diagnosis.

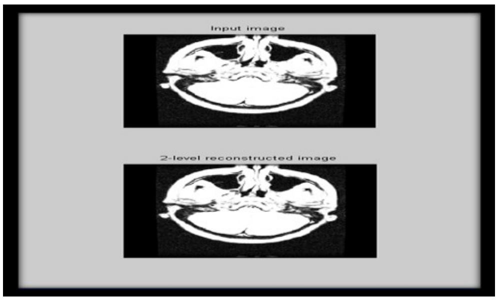

Figure 6: 2-level reconstructed image for wavelet decomposition

The above results in snap shot clearly signifies that the two level decomposition for image compression is quiet reliable and can be seen and processed for the input image which are during the compression process. The 2-level decomposition results found by applying inverse wavelet transform methods for requisite parameters under the taken process.

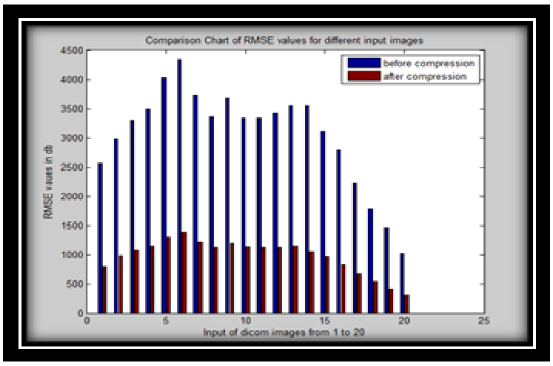

Figure 7: Comparison chart of RMSE values for different images for Wavelet HAAR

As seen from the figure which clearly depicts the comparison chart of root mean square value for all the different images taken and get results one by one. The results are totally base over before compression and after compression values for the input images.

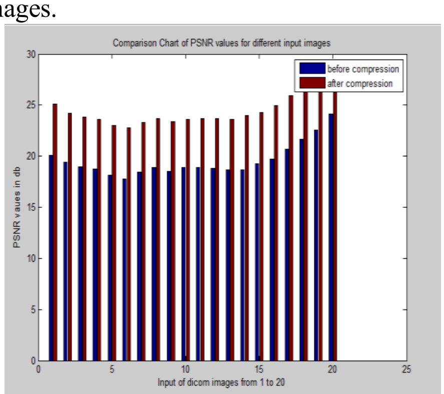

Figure 8: Comparison chart of PSNR values for different input images for Wavelet HAAR

As seen from the figure which clearly depict the comparison chart of peak signals to noise ratio for all the different images taken and get results one by one. The results are totally based over before compression and after compression values for the input images. The above results clearly depicts that the PSNR values after compression for each images are quiet high as compare to before compression of image which is quiet reliable and good for the entire simulation process.

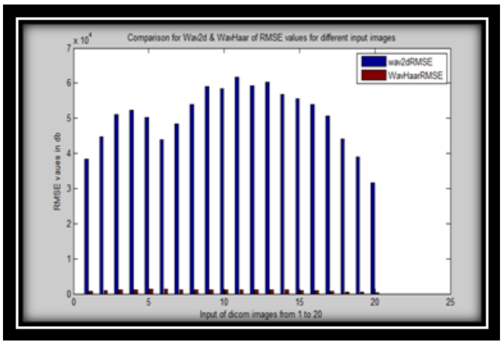

Figure 9: Comparison of Wavelet2d and proposed (Wavelet HAAR) of RMSE values for different input images

The figure is the comparison chart analysis of RMSE values for Wavelet2d techniques and the proposed Wavelet HAAR techniques. As seen from the above graph the results of RMSE values for different set of datasets are quiet reliable and robust for image compression process.

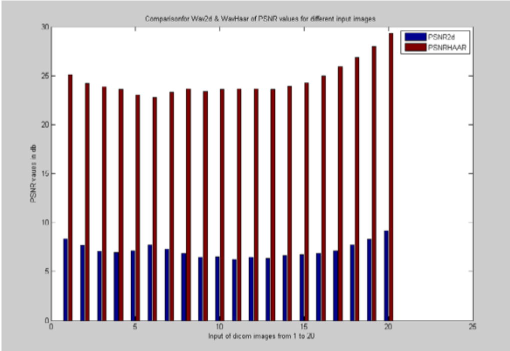

Figure 10: Comparison of PSNR values for both Wavelet 2d and proposed method

The above figure clearly depicts the comparison of both techniques on the basis of PSNR values. The above results quiet familiarize that the values of Wavelet HAAR transform is quiet reliable and optimist as compare to Wavelet 2d transform.

V. CONCLUSIONS

In this work, we have stressed towards the compression of DICOM images using DWT. Digital Imaging and Communications in Medicine (DICOM) is a standard image format for distribution and viewing of medical images from different modalities .Nowadays, due to medical advancement the usage of medical images became necessary for diagnosis of patients. It is the recommended format for medical images, which provides information pertaining to an image, imaging modality and patient in a header The performance and comparison was made over each images stored in the set of data set of DICOM images. Here, we have taken two metrics namely PSNR and RMSE. The results clearly depicts that the value of PSNR for all the images stored in the set of dataset is high after compression in compare to the value of before compression which is quiet good, reliable and scalable for data storage and removes the data redundancy. The performance of our proposed method of DWT using HAAR process is measured over various images and observed the results for both decomposition levels. The proposed algorithm scheme has given superior image compression results for DICOM images.

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