Region of Interest Based Lossless and Lossy Compression for Digital Images

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Abstract— **Image compression is internationally recognized up to the minute tools for decrease the communication bandwidth and save the transmitting power. It should reproduce a good quality image after compressed at low bit rates. Set partitioning in hierarchical trees (SPIHT) is wavelet based computationally very fast and among the best image compression based transmission algorithm that offers good compression ratios, fast execution time and good image quality.**

Aiming at shortage of the SPIHT algorithm, an improved image compression algorithm is proposed, in order to over-come the shortcomings of decoding image quality and coding time, LS9/7 lifting wavelet transform is adopted. Ac-cording to the characteristics of the human visual system (HVS), the scanning mode and the method to determine the threshold of algorithm are changed to improve the quality of reconstruction image.

To solve this problem image compression is a well known technique from many years, which is presented in this paper via a Region of Interest (ROI) based concept. Here, ROI part is compressed via Integer wavelet transform in a lossless manner and SPIHT is used for efficient lossy compression for rest of the regions. Implementation of algorithm is done on MATLAB and parameters such as CR & PSNR are used for evaluating the performance of the system. The results shows that ROI based compression have better performance in terms of image quality, PSNR and bandwidth requirement with preserving the critical information as compare to compression result on the whole image.

Index Terms— **Wavelet Transformation, Region of Interest (ROI), SPIHT, IWT, Integer Wavelet, compression ratio.**

I. INTRODUCTION

The fast development of computer applications came with high increase of the use of digital images, especially in the area of multimedia, games, satellite transmissions and digital imagery. Digital form of the information secures the transmission and provides its manipulation. Constant increase of digital information quantities needs more storage space and wider transmission lines. This implies more the research on effective compression techniques. The basic idea of image compression is the reduction of the middle number of bits by pixel (bpp) necessary for image representation.

The digital representation of images and videos allows processing and archiving tasks to be integrated in multimedia platforms, computing and communications. The increasing demand for multimedia content such as digital images and video has led to great interest in research into compression techniques. The development of higher quality and less expensive image acquisition devices has produced steady increases in both image size and resolution, and a greater consequent for the design of efficient compression systems. Although storage capacity and transfer bandwidth has grown accordingly in recent years, many applications still require compression. In this thesis investigates still image compression in the transform domain. Multidimensional, multispectral and volumetric digital images are the main topics for analysis. The main objective is to design a compression system suitable for processing, storage and transmission, as well as providing acceptable computational complexity suitable for practical implementation. The basic rule of compression is to reduce the numbers of bits needed to represent an image.

In general two techniques of image compression can be used: Lossy and Lossless. Although Lossy compression schemes results in higher compression ratio, yet they are not acceptable to be used for both clinical and legal reasons. However Lossless compression algorithms such as JPEG2000 and wavelet-based compression can produce images statistically identical diagnostic results compared with the original images without any loss [2, 3], therefore lossless image compression is important and more suitable for digital image because any information loss or error caused by the image compression process could affect the clinical diagnostic process [4]. But, as previously mentioned, high compression ratio is strongly recommended. So, the aim of this paper is to present a novel approach which provide a good CR but with maintaining all essential information i.e. high PSNR.

II. DIGITAL IMAGE COMPRESSION

A digital image for Compression can be a single image or sequence of images. Table I shows typical sizes of some digital images which indicates that a compression technique is needed that results with greater data reductions and hence transmission speed. In digital cases, a lossy compression method that preserves the diagnostic information is necessary. Visually indistinguishable resultant images at high quality can be obtained using lossy compression techniques, for compression rates much greater than those obtained by lossless compression techniques. Recently ROI based coding has also been proved as a good approach for medical image compression especially in telemedicine applications. Region of interests (ROI) are those regions which can be given more importance in any given image.

If loss of quality is affordable, then many compression schemes produce high compression rates for general images. However, medicine cannot afford any deficiency in diagnostically important regions (ROI). Thus it is necessary

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to have an approach that brings a high compression rate maintaining good quality of the ROI. Since all regions of digital images do not have equal importance. Special consideration is given only to a few item(s) of the image [5]. Such as for Lena Image, instead of scanning the whole image the section of image that contains the tumor is examined. Which results in high reconstruction quality over user specified spatial regions in a limited time. Lossless compression, Progressive transmission and region of interest (ROI) are necessary requirements for a image compression scheme.

TABLE I
Typical Matrix Sizes for Different Types of Digital Diagnostic Images

Digital Imaging Modality	Matrix Size and Typical Bit Depth
Nuclear Medicine	128 x 128 x 12
Magnetic Resonance Imaging	256 x 256 x 12
Computed Tomography	512 x 512 x 12
Digital Subtraction Angiography	1024 x 1024 x 10
Computed Radiography	2048 x 2048 x 12
Digital Radiography	2048 x 2048 x 12
Digital Mammography	4096 x 4096 x 12

III. SPIHT/IWT ALGORITHM

A. SET PARTITIONING IN HIERARCHICAL TREES (SPIHT)

1) Partition Rules of Algorithm

The main idea of SPIHT algorithm [12, 13] is by reduced progressively threshold sequence generating a series of important diagram (or bitmap) to approximate every wavelet coefficients gradually.

For any node (i , j) bring in four sets as follow:

O (i, j): The coordinate sets of the four direct subsequent node of (i, j);

D (i, j): The coordinate sets of all the subsequent node of (i, j);

L (i, j): The coordinate sets of the entire subsequent node except direct subsequent node of namely:

L (i, j) = D (i, j) - O (i, j)

H: The top of coordinate sets in decomposition of the wavelet pyramid.

For all child nodes except root node of (i,j) =
O (i, j) = {(2i, 2j) , (2i, 2j+1), (2i+1, 2j), (2i+1,2j+1)}

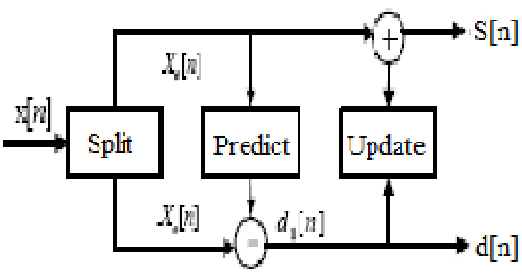

Figure 1 Decomposition of lifting algorithm

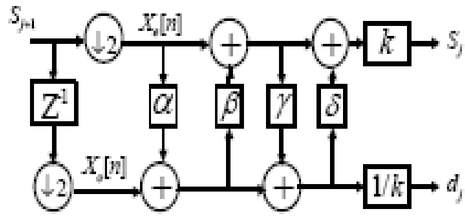

Figure 2 9-7 integral lifting wavelet schemes

a) The initial segmented set consists of (i,j)and D(i,j) , *D*(i,j) ε H

b) If D (i,j) is important, split it into and four single element sets. (k,l) ε (i,j)

c) If L (i, j) is important, split it into four sets
D(i,j) , (k,l) ε O (i, j)

The basic operations of SPIHT algorithm are set test, it description as follows:

$$S_n(i,j)=\begin{cases}1, \max_{(i,j)\in T}\{|C(i,j)|\}\geq 2^n\\ 0, \text{ others}\end{cases}$$

2) Algorithm Description

SPIHT algorithm consists of three linked list to record coding information:

LIS: List of Insignificant Sets;

LIP: List of Insignificant Pixels;

LSP: List of Significant Pixels;

a) Initialization

Suppose,

$$T=2^n, n=\lfloor \log_2(\max_{(i,j)}|c_{i,j}|)\rfloor$$

$C_{i,j}$ are wavelet coefficients, the initial LSP is empty

LIP= {(i,j) | (i,j) ε H}

LIP= {D(i,j) | (i,j) ε H} are coordinate sets of all roots.

(b) Fine Scanning

This process scanning LSP only, for each of LSP, if (i,j)is not a new add in the scanning process has just, according to the current quantitative threshold Tn, judging the size of the most significant bit of the wavelet coefficients, and output the n^{th} important bit of $|C_{i,j}|$in binary.

(c) Update the Threshold

Order n = n + 1 and quantized threshold as $T_{n+1} = T_n$ for the next scanning. For LIP, LSP and LIS use the same rules to update.

B. INTEGER WAVELET TRANSFORM (IWT)

The integer wavelet transform was developed by [15] based on the lifting scheme presented by [17]. Although this transform does not make use of dilation and translation of a mother wavelet like the regular wavelet transform, it is able to keep the multi-resolution properties of the wavelet transform. To obtain the low frequency component si-1 and the high frequency coefficients di-1 that the wavelet transform forms by transforming a signal si, the integer wavelet transform operates on three steps: split, prediction, and update.

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IV. PROPOSED WORK

The proposed work can be obtained by integer wavelet transform followed by SPIHT algorithm.Fig.1 Shows the general architecture of the proposed system. The proposed image compression and reconstruction architecture addressed in this paper involves the following steps.

- Browse the digital image as input.
- Using a Global thresholding method, Apply threshold to remove background i.e. the ROI & Non-ROI regions are separated from background (BG).
- Select ROI, and separate out ROI and Non-ROI.
- ROI region is encoded using IWT with high bpp.
- Non-ROI region is encoded using SPIHT with low bpp.
- Merge the two encoded regions (ROI and Non-ROI) to get the ROI based compressed image.
- To perform Non-ROI compression i.e. compression without any particular selection of Region applies SPIHT on the binary image, obtained in step (ii).
- Get the Non-ROI based compressed image.
- Compare the quality of ROI based compressed image with Non-ROI based compressed image obtained in previous steps in terms of PSNR and compression ratio.

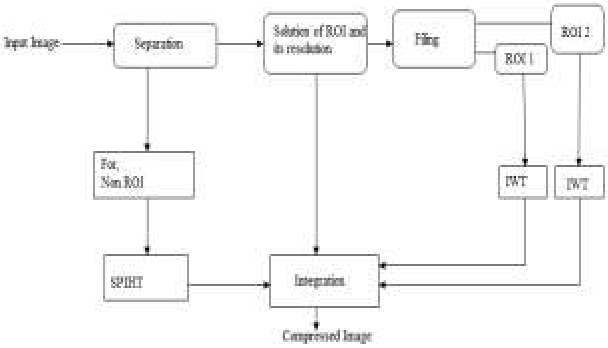

Figure 3 Flow chart of proposed work

A. *Region of Interest*

Those regions of an image which are given more consideration as compare to other regions are called region of interest i.e. ROI. It is a general observation that in some real image or digital image all the regions do not show equal importance for examination point of view. Considering this fact, attention is paid only to selected parts of the image [16].

The Region of Interest (ROI) concept is important because of the limitation and hampering of images due to lossy and lossless compression techniques. The compression ratio of lossless compression techniques result into 25% of original size, while for the lossy encoder's compression ratio is much greater, but both of these compressions causes loss in the data [17]. This loss in data may cramp the important part of image. So to get rid from this problem, a better compression technique is needed which provide a better compression ratio by taking care of the important part (ROI) of the images.

B. *ROI Based Coding*

To fulfill the need of high compression rate, another approach for lossy compression may be ROI (Region of Interest) based coding. In this approach instead of transforming the whole image, the same transformation can be separately applied to the diagnostically important regions and background. In a medical image ROI is selected according to a predetermined characteristic or as per users need. The goal of such compression method is to maximize the overall CR i.e. compressing each region separately with its own CR, depending on its significance, so as to preserve the diagnostically important characteristics. Hence, such a strategy that exploits the feature of ROI is becoming beneficial and compact, providing better CRs and fast processing especially on a low bandwidth media. Further, ROI coding provides an excellent trade-off between image quality.

V. EXPERIMENTAL RESULTS

The background parts of the input images are separated by applying threshold segmentation algorithm. The ROI part of the image separated from image after that the compression algorithm that can be applied on that ROI part of the image. Then the reverse part of the compression algorithm is used to obtain original image. We are selected the input image as figure 4 and select ROI in figure 5 after that figure 6 Lena image are selected with ROI.

Figure 4 input image

Figure 5 Select ROI

Figure 6 Selected ROI

REGION OF INTEREST SELECTED IMAGE

Image compression has applied on Lena image at different compression rates. Figure 7 is an original image when ROI method is selected so its compression must be in a lossless manner, and in lossless manner IWT Algorithm applies. Figure 7 shows evaluation parameter PSNR=50.897606 and Comprn=75.320435 with ROI compress image.

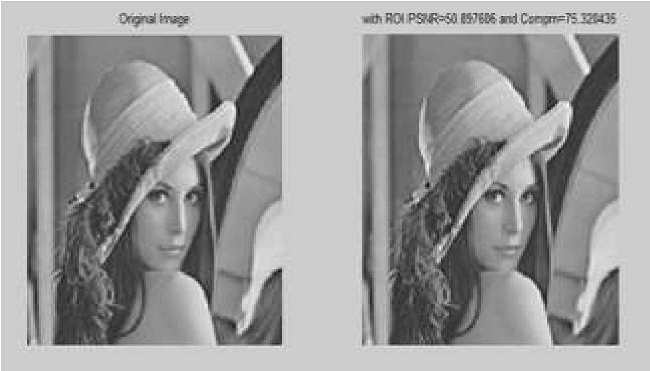

Figure 7 Original Image and With ROI PSNR=50.897606 and Comprn=75.320

Image compression has applied on Lena image at different compression rates. Figure 8 is an original image when ROI method is selected so its compression must be in a lossless manner, and in lossless manner IWT Algorithm applies. Figure 8 shows evaluation parameter PSNR=52.749981 and Comprn= 77.853394 with ROI compress image.

Figure 8 Original Image and With ROI PSNR=52.749981 and Comprn=77.853394

Image compression has applied on Lena image at different compression rates. Figure 9 is an original image when ROI method is selected so its compression must be in a lossless manner, and in lossless manner IWT Algorithm applies. Figure 9 shows evaluation parameter PSNR=54.541440 and Comprn=80.229187 with ROI compress image.

Figure 9 Original Image and With ROI PSNR=54.541440 and Comprn=80.229187

Image compression has applied on Lena image at different compression rates. Figure 10 is an original image when ROI method is selected so its compression must be in a lossless manner, and in lossless manner IWT Algorithm applies. Figure 10 shows evaluation parameter PSNR=55.876681 and Comprn=82.743835 with ROI compress image.

Figure 10 Original Image and With ROI PSNR=55.876681 and Comprn=82.743835

Image compression has applied on Lena image at different compression rates. Figure 11 is an original image when ROI method is selected so its compression must be in a lossless manner, and in lossless manner IWT Algorithm applies. Figure 11 shows evaluation parameter PSNR=57.489429 and Comprn=85.209656 with ROI compress image.

Figure 11 Original Image and With ROI PSNR=57.489429 and Comprn=85.209656

Image compression has applied on Lena image at different compression rates. Figure 12 is an original image when ROI method is selected so its compression must be in a lossless manner, and in lossless manner IWT Algorithm applies. Figure 12 shows evaluation parameter PSNR=68.111906 and Comprn=110.360718 with ROI compress image.

Figure 12 Original Image and With ROI PSNR=68.111906 and Comprn=110.360718

Image compression has applied on Lena image at different compression rates. Figure 13 is an original image when ROI method is selected so its compression must be in a lossless manner, and in lossless manner IWT Algorithm applies. Figure 13 shows evaluation parameter PSNR=69.105514 and Comprn=112.847900 with ROI compress image.

Figure 13 Original Image and With ROI PSNR=69.105514 and Comprn=112.847900

NON REGION OF INTEREST (ROI) SELECTED IMAGE

Image compression has applied on Lena image at different compression rates. Figure 14 is an original image when Non ROI method is selected so its compression must be in a lossy manner, and in lossy manner SPIHT Algorithm applies. Figure 14 shows evaluation parameter PSNR=37.202724 and Comprn=16.850281 with Non ROI compress image.

Figure 14 Original Image and Without ROI PSNR=37.202724 and Comprn=16.850281

Image compression has applied on Lena image at different compression rates. Figure 15 is an original image when Non ROI method is selected so its compression must be in a lossy manner, and in lossy manner SPIHT Algorithm applies. Figure 15 shows evaluation parameter PSNR=39.275405 and Comprn=20.124817with Non ROI compress image.

Figure 15 Original Image and Without ROI PSNR=39.275405 and Comprn=20.124817

Image compression has applied on Lena image at different compression rates. Figure 16 is an original image when Non ROI method is selected so its compression must be in a lossy manner, and in lossy manner SPIHT Algorithm applies. Figure 16 shows evaluation parameter PSNR=41.471323 and Comprn=23.481750 with Non ROI compress image.

Figure 16 Original Image and Without ROI PSNR=41.471323 and Comprn=23.481750

Image compression has applied on Lena image at different compression rates. Figure 17 is an original image when Non ROI method is selected so its compression must be in a lossy manner, and in lossy manner SPIHT Algorithm applies. Figure 17 shows evaluation parameter PSNR=43.232214 and Comprn=26.730347 with Non ROI compress image.

Figure 17 Original Image and Without ROI PSNR=43.232214 and Comprn=26.730347

Image compression has applied on Lena image at different compression rates. Figure 18 is an original image when Non ROI method is selected so its compression must be in a lossy manner, and in lossy manner SPIHT Algorithm applies. Figure 18 shows evaluation parameter PSNR=44.837925 and Comprn=30.055237 with Non ROI compress image.

Figure 18 Original Image and Without ROI PSNR=44.837925 and Comprn=30.055237

Image compression has applied on Lena image at different compression rates. Figure 19 is an original image when Non ROI method is selected so its compression must be in a lossy manner, and in lossy manner SPIHT Algorithm applies.

Figure 19 shows evaluation parameter PSNR=57.932713 and Comprn=63.237000 with Non ROI compress image.

Figure 19 Original Image and Without ROI PSNR=57.932713 and Comprn=63.237000

Image compression has applied on Lena image at different compression rates. Figure 20 is an original image when Non ROI method is selected so its compression must be in a lossy manner, and in lossy manner SPIHT Algorithm applies. Figure 20 shows evaluation parameter PSNR=58.996235 and Comprn=66.534424 with Non ROI compress image.

Figure 20 Original Image and Without ROI PSNR=58.996235 and Comprn=66.534424

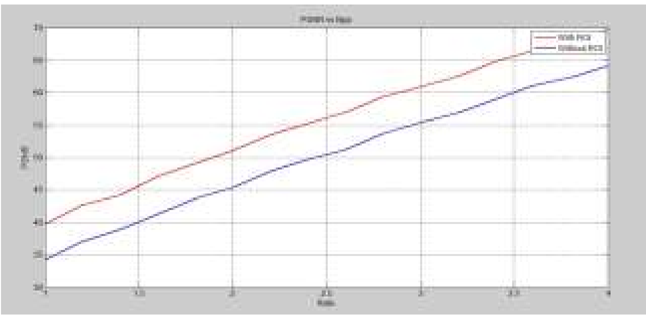

Figure 21 PSNR vs BPP

VI. Conclusion

From the presented work in this paper, it can be concluded that Region Based Coding Technique is significant for telemedicine application i.e. digital image compression and their transmission over the network. Concerning the digital imaging, only a small portion of any particular image might be diagnostically important. So this fact is utilized in the present work, i.e. in selected regions, lossless compression can helps to achieve high efficiency performance. The easier MATLAB simulation & corresponding results prove it, a very efficient and low complexity compression method for digital images. Manual identification of ROI is done here and further combined with effect of Integer Wavelet Transform (IWT), also SPIHT has many advantages, such as good image quality, high PSNR and good progressive image transmission which has been used for lossy compression in the proposed work. Evaluation has been done with the help of Lena image and it shows that both techniques are useful to reconstruct the original image, reversibly with desired quality, especially in limited bandwidth over a telemedia application. The work shows a good result for natural image also.

The proposed work can be extended with automatic selection of ROI rather than manual and also on the basis of information contents present in the image. The most demanding area is the need for a system which automatically extracts the region of interest and proceeds as stated above.

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