Contextual Region of Interest Based Medical Image Compression using Contextual Listless SPIHT Algorithm for Brain Images

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Abstract- Medical Imaging plays a major role in medical diagnosis. Storing these medical images and transmitting them is quite challenging. Due to the extensive use of medical images like CT and MR scan, the application of digital imaging technology in the medical domain has grown rapidly. These medical imagery are stored for a longer period for the continuous monitoring of the patients. So, the medical images need to be compressed to reduce the storage cost and for transmission without any loss. In this paper, a context based method called Contextual Listless Set Partitioning in Hierarchical Trees (CLSPIHT) algorithm for brain images is proposed to overcome this challenge.   Here, the region containing the most inportant information for diagnosis purpose is referred as contextual region of interest. In this method, the Contextual Region of Interest(CROI) is encoded separately with a low compression rate ie, with high bpp and the Back Ground region(BG) is encoded with low bpp. Finally, the two regions are merged together to construct the output image. Our experimental results show that the proposed Contextual Listless SPIHT (CLSPIHT) yields very good image quality without any diagnostic loss. Compression performance parameters (Mean Square Error, Peak Signal to Noice Ratio, and Coefficient of Correlation) are improved by our method and it is compared with the other existing methods of JPEG2000,and the ROI based methods such as CSPIHT and CVQ on magnetic resonance images. As a result, it is found that our proposed algorithm gives better results and using this method, we can overcome the limitations in storage and transmission of medical images.

Keywords: CLSPIHT, CROI, BG,MSE,CR,PSNR, CoC, MR images

I.INTRODUCTION

Nowadays, Magnetic Resonance(MR) Images play a vital role in diagnosing various diseases. The medical images have to be stored and retrieved for frequent analysis. Medical image compression techniques play a major role in storing and transmitting the medical images in various applications such as telemedicine, health care , medical sciences etc. All the important information needed for diagnosis will be preserved only if the compression techniques are effective. The main aim of compression techniques is to maintain all the necessary information needed for diagnosing the digital images. There are many imaging devices that continue to produce large amount of data per patient which needs storage and transformation for continuous monitoring.

Many compression algorithms[1] produce high compression rates with affordable loss of quality but physician may not accept any loss in diagnostically important regions of images. The region which contains the more important information for diagnosis is referred to as region of interest[7,10,13]. The main challenge in compressing medical images is to compress the ROI region without any loss of important information.

In our work, we propose a new technique based on ROI . Normally ROI is selected based on wavelet based compression techniques. There are several ROI based methods presented by researchers. Most popular method is based on SPIHT[3,4,7,10] and the other methods are based on bit plane coding techniques[2,8].

The proposed Contextual Listless Set Partitioning in Hierarchical Trees [CLSPIHT] method gives excellent performance with comparable efficiency and a high quality of reconstructed image.

The Contextual LSPIHT allows certain parts of an image which contains important information to be coded with high bit rate compared to the background which contains the patient's information. The Contextual Regions and the background regions are encoded separately with high bit rate and low bit rate respectively. Then the two encoded images are merged to get a compressed image.

II.RELATED WORKS

For ROI coding, JPEG2K [2,16]is the first method that uses a scaling method of coding. In this method, ROI shape is limited to circles and rectangles. The scaling methods lead to two major problems in

encoding. First, it needs to encode the ROI shape and if the shape is arbitrary then coding will consume more no of bits which minimizes the efficiency of coding.

Another method for ROI is the Maxshift method[6,11], which lacks in flexibility in scaling value and overflow of bitstream. Contextual SPIHT (CSPIHT) algorithm for ultrasound image compression method is introduced by Ansari and Anand[5]. This method also encodes the CROI and the BG information separately.

Embedded Block coding is another ROI based method, introduced by Tauman[8]. The main advantage of this method is to get a target compression ratio and need not perform multiple compression. But this method suffers from very high computational complexity.

Recently, S.M.Hosseini et al[9], proposed a technique based on Contextual vector quantization for CT image compression. In our work, we propose a similar contextual based technique for the compression of Magnetic Resonance Images which uses Listless SPIHT instead of CSPIHT.

III. Overview of ROI Coding Techniques

A. Scaling Method by JPEG2K

In JPEG2K, ROI coding is the scaling method in which the wavelet coefficients belonging to the contextual regions are shifted upward. Moreover this method allows the use of arbitrary scaling value. But it has some drawbacks. First, the shape information of the ROI needs to be encoded. Second, if arbitrary ROI shapes are selected then the coding will consume more number of bits which in turn decreases the overall efficiency of coding.

B. Maxshift

This method (defined in JPEG 2K-part 1) uses the arbitrary scaling value without the need for transmitting the shape information to the decoder. Here, the mapping is based on the wavelet filters[1] which maps the ROI from the spatial domain to the wavelet domain. Wavelet coefficients [12]that are not part of ROI are scaled down. The main advantage of this method is that encoding of arbitrarily shaped ROI is possible without the shape information.

C.Contextual SPIHT

Mostly, DWT[1,17] is applied on the whole image in conventional image compression methods, but in the contextual based coding, different thresholds are applied to the wavelet coefficients of each band to get better compression ratio. CSPIHT uses different compression rates to wavelet coefficients in different CROI. Segmentation approach is used to separate CROI and not the BG.

D. Contextual Vector Quantization

This method is also based on Contextual SPIHT method. Here instead of SPIHT, Vector Quantization [14]is used to encode the image parts. The main aim of this approach is to separate CROI and background (BG) and then encode both regions using CVG. Here the CROI is encoded with high bit rate and the BG is encoded with low bit rate. Finally, the two images are merged to get the compressed image.

IV. PROPOSED CONTEXTUAL LISTLESS SPIHT

In this section, we propose a novel wavelet based compression[17] method which uses a ROI technique to extract the important information and Back ground image. In this, the diagnostically important region (CROI) and the BG are encoded separately using Contextual Listless SPIHT (CLSPIHT). The CROI is encoded separately using CLSPIHT with high bpp and the BG is encoded using CLSPIHT with low bpp. Finally, the two encoded regions are merged together to get the compressed image.   The flow diagram of the proposed method is shown in Figure 1. Listless Set Partitioning in hierarchical trees (LSPIHT)[20,21] uses the set structure and partitioning rules. It uses a set partitioning rules of SPHIT without using any list. In the listless SPIHT,the wavelet coefficients are arranged in recursive z ordering with single linear index and the indexing is used to track the set partitioning. To store the significant and insignificant coefficients, state markers are used. Markers are used for each pixel to identify insignificant/significant and newly significant coefficients and there are five markers to mark the state of sets as well as to denote the spatial resolution level of these sets.
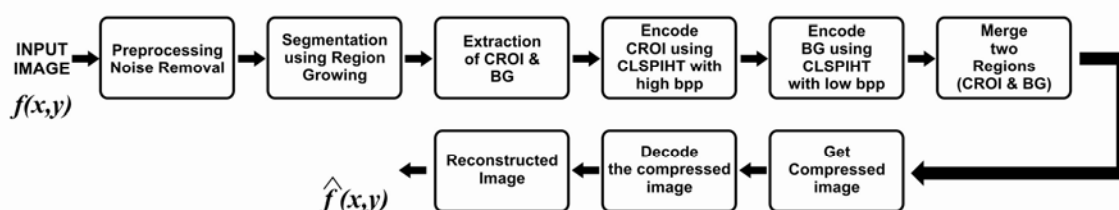

Figure 1. Proposed Contextual Listless SPIHT Algorithm.

Initially, the LL sub band coefficients are marked as Mark='1' and others are assigned the value as Mark='0'. In the sorting pass, the significant coefficients are marked as mark=2, and encoded by sign and magnitude bits. In the refinement pass, all the coefficients which are marked as mark=3 is refined.

Here five markers are being used for significant or insignificant sets and to know the state of the nodes of trees. Each tree node which lies in the LL sub band is marked initially as Mark=5, and the others are marked as mark=0. In the Scanning pass, if a tree that lies in the present spatial resolution level are tested for significance and if it is type A and is coded by one significant bit and the set is being partitioned into four children and a grand descendant. The first four descendants are checked for the significance and the output is coded by sign and the magnitude. The pixel states are updated accordingly.

The grand descendants are processed for the significant test and it they found significant, four new type A with offspring as root node is being formed with the Mark='5' and root node is reassigned to the value Mark='4', otherwise it is type B with Mark='6'. If there are no type A nodes in the spatial region, next spatial region is checked for significance and marked as Mark='7'. The type B is marked as mark=8, if it does not lie in the present spatial region. In the next spatial region, the mark=7 is changed to mark=5 and mark=8 is to mark=6 and again checked for significance.

In this way, all the coefficients corresponding to the same spatial resolution level are encoded and the undesired coefficients are discarded. If the desired bit rate and compression ratio is achieved, then the encoding can be terminated.

A. Region Separation

Segmentation approach[15] is applied to separate the contextual region and the background images. For the segmentation of regions, techniques like region growing[19], edge detection are used. In our approach, region growing method is used to separate the CROI and the background regions. The main aim of this region growing technique is to group spatially connected pixels which lies within a small range. By this method, the original image is divided into some predefined regions. Based on some criterion, the pixels may be merged together to form a larger regions. From this, we need a seed point. From that seed point, the neighboring pixels are checked with region growing condition. That is, pixels which have similar attributes are appended to form a larger region. Based on the condition, the growing algorithm appends the similar pixels. Normally, similarity can be measured in terms of the difference between the pixel's intensity value and the mean of region corresponding to that particular pixel. The process is recursively repeated until no spatially connected pixels meet the condition. The procedure is repeated for all the pixels to include any one of the regions based on the condition.

B. Proposed Contextual Listless SPIHT (CLSPIHT) algorithm

1. Load the input image
2. In the preprocessing, Gaussian Filtering is applied to eliminate noise if any
3. Using a region growing method, the CROI and BG are separated
4. CROI region is encoded using CLSPIHT with high bpp
5. BG region is encoded using CLSPIHT with low bpp
6. Merge the two encoded regions (CROI and BG) to get the compressed image
7. Decode the compressed image to get the reconstructed image
8. The image is correlated with the original image, if the correlation is not satisfactory, bit rates are reassigned to CROI and BG and the process is repeated till the desired bpp and CR is achieved.

C. Performance Metrics

The efficiency of the compression algorithm is measured in terms of performance measuring parameters[18] such as Compression Ratio (CR), Peak Signal Noise Ratio (PSNR), bit rate (bpp), mean square error (MSE) and Correlation coeeficient (CoC)[5,9].

1. Peak Signal to Noise Ratio (PSNR)

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right)dB \qquad (1)$$

2. Compression Ratio

$$CR = \frac{Size\ of\ the\ compressed\ image}{Size\ of\ the\ uncompressed\ image} \qquad (2)$$

3. $MSE = \dfrac{1}{M.N} \sum\limits_{x=1}^{M} \sum\limits_{y=1}^{N} \left| f(x,y) - \hat{f}(x,y) \right|^2$ (3)

4. $CoC = \dfrac{\sum\limits_{x=1}^{M} \sum\limits_{y=1}^{N} f(x,y).\hat{f}(x,y)}{\sqrt{\sum\limits_{x=1}^{M} \sum\limits_{y=1}^{N} f(x,y)^2} \sqrt{\sum\limits_{x=1}^{M} \sum\limits_{y=1}^{N} \hat{f}(x,y)^2}}$ (4)

V.EXPERIMENTAL RESULTS AND DISCUSSIONS

The proposed method is implemented and tested using the image processing software tool, MATLAB 7.9. We considered magnetic resonance brain images for the test purpose. The performance parameters bpp, Compression ratio (CR), Mean square error (MSE), Peak Signal to Noise Ratio (PSNR) and Correlation Coefficients (CoC) are given in Table.I & II. The parameters are obtained separately for CROI region and the entire image area. Figure 5. Show the original image and the extracted CROI region, BG and the reconstructed image is obtained by merging the two extracted regions.

The compression parameters for several compression ratios for CROI region and the entire image is listed in Table I. and the comparison of bpp with MSE,CR,PSNR are analysed and plotted in Figure 2(a-d). Table II. Shows the same performance parameters of compression for background (BG) image and the complete image and plotted in Figure 2.(e-h).

Table I. CLSPIHT- CROI Region and the full image parameters

Sl.no	bpp	CROI region				Full image			
		CR	MSE	PSNR(dB)	CoC	CR	MSE	PSNR(dB)	CoC
1.	1.0000	4.643	10.01	40.29	0.998	10.09	198.23	34.293	0.978
2.	0.9000	6.649	12.20	39.81	0.991	14.67	204.719	33.085	0.970
3.	0.8000	7.619	12.85	39.01	0.989	15.84	208.183	32.962	0.968
4.	0.7000	8.983	13.50	37.98	0.987	17.93	210.426	32.183	0.964
5.	0.5000	10.195	14.04	37.03	0.985	20.01	219.807	31.090	0.961
6.	0.4000	11.983	14.97	36.76	0.983	24.87	228.381	30.520	0.960
7.	0.3000	12.042	15.40	36.52	0.981	30.72	237.901	29.105	0.957
8.	0.2500	14.364	17.52	35.61	0.979	44.10	243.042	28.846	0.954
9.	0.1250	18.293	20.51	35.02	0.975	127.85	313.01	27.058	0.942
10.	0.0625	20.148	21.93	34.28	0.968	256.13	398.63	26.285	0.920

Table III. shows, our proposed methods outperforms all the existing methods such as Maxshift,CSPIHT,CVQ interms of PSNR and CoC and also plotted in Figure 3. To show our proposed method is even better than the general compresson methods of JPEG2000, SPIHT, it is compared in terms of same PSNR and CoC and it is plotted in Figure 4.

We considered 10 different bitrates for CROI and BG, and achieved better compression quality compared to the existing methods. Our proposed method's advantage over all the listed method is more evident as the compression ratio increases. It is clearly stated in the Table III and Table IV and also plotted in Figure.3 & 4. Our proposed method keeps all the important information needed for the diagnostic purposes with out any loss in the quality.

Table II. CLSPIHT- BG region and the full image parameters.

| Sl.no	bpp	BG region				Full image			
		CR	MSE	PSNR(dB)	CoC	CR	MSE	PSNR(dB)	CoC
1.	1.0000	10.68	184.201	28.230	0.962	10.09	198.23	34.293	0.978
2.	0.5000	21.034	186.832	28.102	0.958	14.67	204.719	33.085	0.972
3.	0.4000	25.890	187.381	27.572	0.958	15.84	208.183	32.962	0.968
4.	0.3000	34.976	189.490	27.371	0.956	17.93	210.426	32.183	0.964
5.	0.2000	53.019	192.521	27.013	0.951	20.01	219.807	31.090	0.963
6.	0.1000	105.962	202.910	25.295	0.943	24.87	228.381	30.520	0.961
7.	0.0800	131.874	229.525	25.192	0.942	30.72	237.901	29.105	0.957
8.	0.0600	176.242	270.672	24.841	0.938	44.10	287.186	28.846	0.954
9.	0.0400	265.031	304.963	23.105	0.914	127.85	328.614	27.058	0.942
10.	0.0200	529.753	361.832	22.031	0.903	256.13	398.203	26.285	0.915
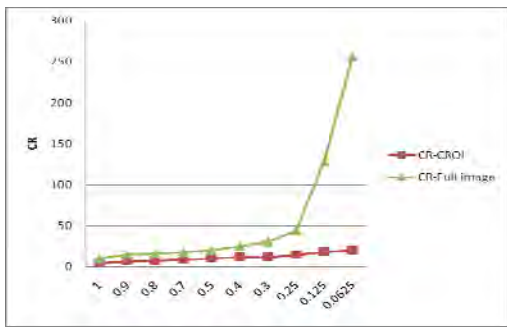
a.bpp vs.CR for CROI and Full image
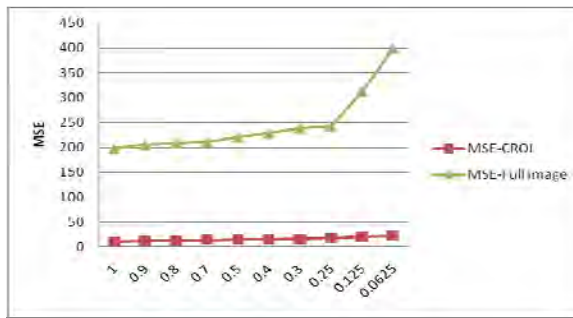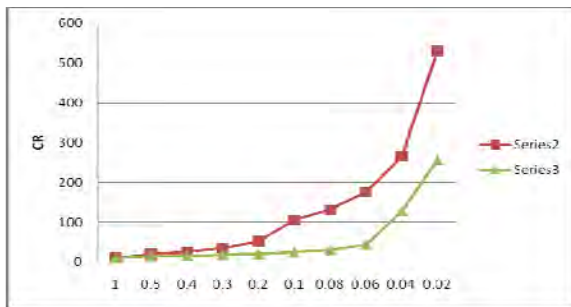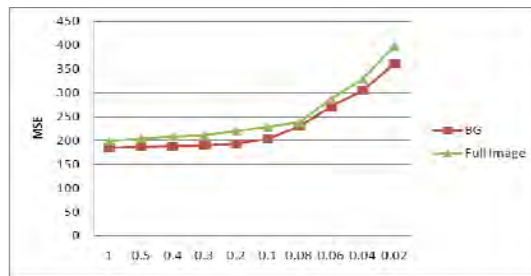

b.bpp vs. MSE for CROI and Full image
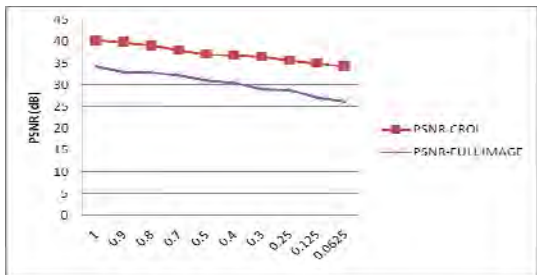
c. bpp vs.PSNR (dB) for CROI and Full image
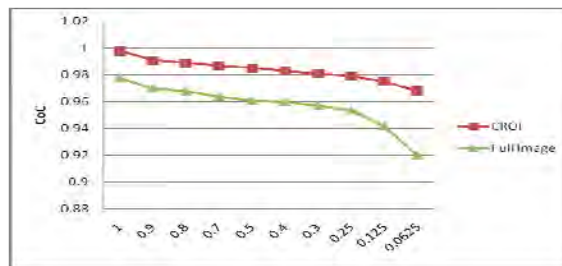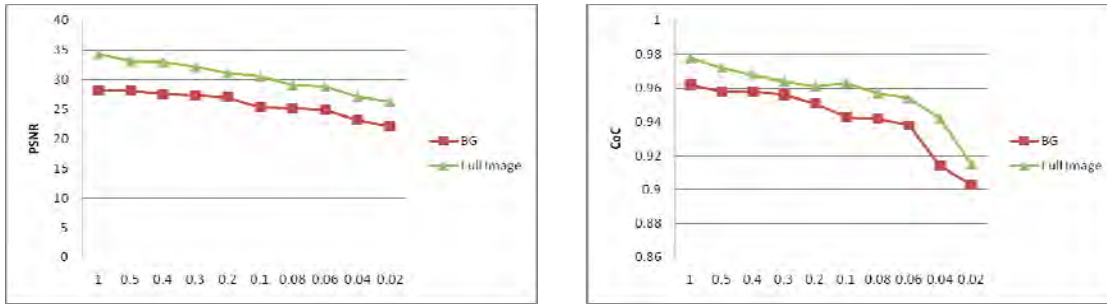

d.bpp vs.CoC for CROI and Full image

e.bpp vs CR for BG and Full image

f.bpp vs. MSE for BG and Full image

g. bpp vs.PSNR (dB) for BG and Full image   h.bpp vs.CoC for BG and Full image

Figure 2.Comparison of compression parameters – bpp vs.MSE,CR,PSNR and CoC for both CROI and BG (CROI and complete image, BG and Complete Iimage) for 10 different bit rates (bpp).

Table III. Comparison of Maxshift, CSPIHT, CVQ and our proposed method (CLSPIHT), in terms of PSNR (dB) and CoC.

bpp	CR	PSNR(dB)				CoC			
		Maxshift	CSPIHT	CVQ	CLSPIHT	Maxshift	CSPIHT	CVQ	CLSPIHT
1.0000	10.57	40.73	40.27	41.32	42.79	0.997	0.998	0.999	0.999
0.5000	34.97	37.28	36.62	39.04	40.13	0.996	0.996	0.997	0.998
0.2500	68.01	32.19	33.81	38.26	39.72	0.995	0.993	0.997	0.999
0.1250	127.85	29.81	29.95	36.39	37.95	0.993	0.992	0.995	0.999
0.0625	256.13	25.04	27.74	34.68	37.26	0.989	0.991	0.996	0.998

Table IV. Comparison of JPEG2000,SPIHT, and the proposed CLSPIHT, in terms of PSNR (dB) and CoC.

bpp	PSNR (dB)			CoC		
	JPEG2000	SPIHT	CLSPIHT	JPEG2000	SPIHT	CLSPIHT
1.0000	34.45	36.49	42.79	0.998	0.999	0.999
0.5000	31.73	33.10	40.13	0.996	0.997	0.998
0.2500	27.41	29.73	39.72	0.991	0.994	0.999
0.1250	26.01	28.05	37.95	0.989	0.989	0.999
0.0625	23.47	26.14	37.26	0.985	0.983	0.998
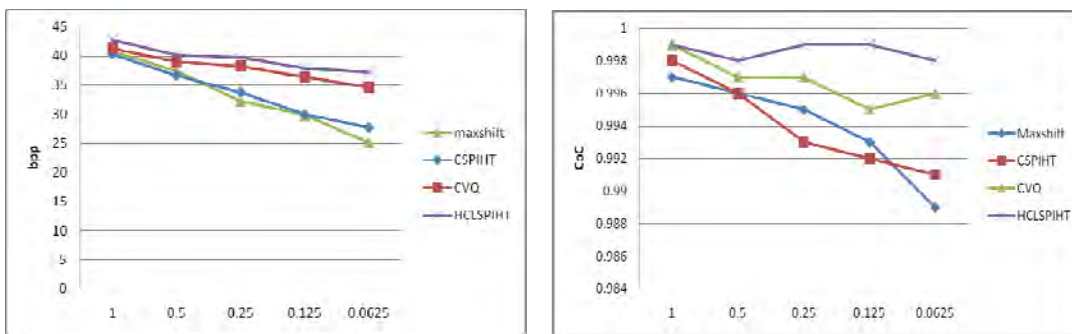
a.bpp vs.PSNR (dB) for Maxshift, CSPIHT,   b.bpp vs.CoC for Maxshift,CSPIHT,
CVQ and our proposed CLSPIHT   CVQ and our proposed CLSPIHT
Figure 3.Comparison of bpp vs.PSNR (dB) and CoC for Maxshift,CSPIHT, CVQ and our proposed method (CLSPIHT).
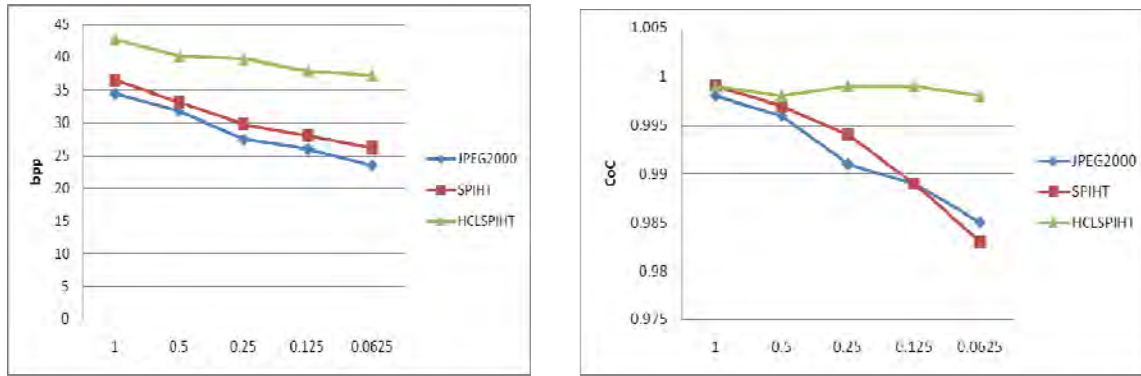
c.bpp vs.PSNR (dB) for JPEG2000,SPIHT,
and our proposed CLSPIHT

d.bpp vs.CoC for JPEG2000,SPIHT,
and our proposed CLSPIHT

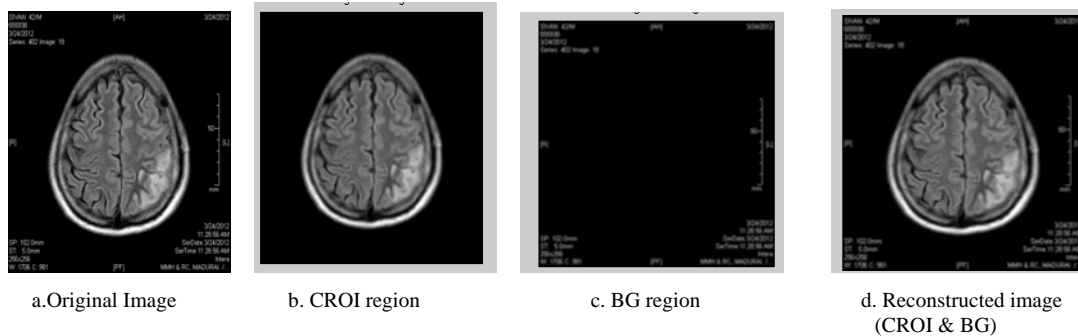Figure 4. Comparison of bpp vs.PSNR (dB) and CoC for JPEG2000, SPIHT and our proposed CLSPIHT

a.Original Image   b. CROI region   c. BG region   d. Reconstructed image
(CROI & BG)

Figure.5 Original image and the separation of CROI and BG, final reconstructed image using our proposed CLSPIHT.

VI.CONCLUSIONS

In this work, we have proposed Contextual Listless SPIHT (CLSPIHT) which uses region of interest concept. Our main idea is to separate the contextual region of interest which contains the most important information for diagnosis and the back ground image which consists of patient information. Here, CROI region is encoded separately and the BG regions are encoded separately using Contextual Listless SPIHT. Finally, the two extracted regions are merged together to get the reconstructed image. The results obtained in this method are listed in Table I and Table II and it clearly show the better performance in terms of PSNR, CR, MSE and CoC for different bit rates. The performance parameters bpp and the PSNR comparative results of different methods are compared and our method show the improved performance. From the comparison with the traditional methods such as JPEG2000 and SPIHT, our method provides better compression performance in terms of PSNR and CoC as well as good visual quality of reconstructed image. So, we conclude that our proposed CLSPIHT method is a good selection for minimizing the storage cost and the transmission time of medical images.

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