On the Performance Characteristics of Embedded Techniques for Medical Image Compression

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Received 05 September 2016; revised 13 April 2017; accepted 26 July 2017

In the recent times Defence Radar and Medical technology used image processing as a useful tool for analysis of information contained in the images. In this paper the technique of focusing the analysis on the region of interest (ROI) and applying different compression methods on the ROI and outside ROI for appreciable compression. The results presented in this paper provided excellent performance with the proposed approach in which SPIHT and the HAAR are involved for segmentation, compression and further fusion. Further the performance showed its performance when compared with the other two techniques in terms of various image metrics.

Keywords: ROI, SPIHT, HAAR, DWT, Medical Image Processing

Introduction

Through image compression it is made possible to transmit large volumes of data to long distances without much loss in the originality of the data¹,² in various industrial, commercial and defence applications. This technique economizes the bandwidth and provides the effective use of the same. In medical diagnosis the technique is modified in order to limit the processing steps by simply applying varying level of compression. For such applications only some part of the data is of importance which is identified as the defective part for further diagnosis. In the entire image, only modest percentage of it is effected are or the area of interest. The technique of focusing on specific region in the image data is considered as region of interest (ROI)³. Several transform techniques are employed for segmentation which is followed by applying several algorithm like Embedded Zero tree Wavelet⁴ (EZW), Set Partitioning in Hierarchical Trees⁵ (SPIHT) and Set Partitioning Embedded Block⁶ (SPECK). The lossless method⁷,⁸ is developed which uses binary WT with almost zero quantisation distortion and is completely invertible. A combination of WT and vector quantization (VQ) was proposed. This method can be applied to medical images where high precision reconstructed image is required. In this method, a 3-level 2-D DWT is firstly applied to the test image and then VQ is used to different sub bands for compression. SPIHT was developed by Said and Pearlman⁹,¹⁰ for wavelet coding of images using parent child dependencies. The technique can be integrated into the current wavelet based embedded image-coding algorithm, and makes it easy to be implemented, effectively transferred and applied. The method adopting Wt and EZW adopts quantification factors to determine some coefficients of high frequency, followed by performing scalar quantization. This algorithm improves not only the accuracy of the scanning process, but also the PNSR as well as the quality of image reconstruction. In this paper, implementation of lossy image compression for medical applications is demonstrated. SPIHT algorithm is used for the purpose. The rest of the paper is organised as follows. Description of the existing methodology to compress the medical images is given in Section 2. The proposed methodology is explained in Section 3. An insight in to the wavelet based compression is provided in Section 4. The description of the lossy encoding techniques is given in Section 5. Simulation based results and the overall conclusion is given in Section 6 and 7.

Existing and proposed strategy

In the existing strategy for medical image compression after specifying the initial parameters like Rate and tolerable error separate the image data into two classes. Allocate the preferred bit budget among

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these two classes with minimum distortion which is followed by Quantization step. Encode each class separately. Finally the compressed image is obtained. During the decompression the quantized data is read using the decoder. Later on de-quantization and further reconstruction of the image is performed.

For quick processing and better interactivity while searching for similarities of the target image in the huge set of images it is often required to keep the images in the database in compressed format. However, in medical imaging, the loss of any information when storing or transmitting an image is intolerable. The rapidly developing medical image sources, and for most of them discarding small image details that might be an indication of pathology could alter a diagnosis, causing severe human and legal consequences. Hence, priority based ROI inherently support for lossy coding. Fast image inspection of large volumes of images transmitted over low bandwidth channels like ISDN, public switched telephone, or satellite networks (traditionally known as teleradiology), requires compression schemes with such progressive transmission capabilities. Moreover, optimal rate-distortion performance over the complete range of bit-rates that is requested by the application should also be considered. Additionally, the increasing use of three dimensional imaging modalities, like Magnetic Resonance Imaging (MRI), Computerized Tomography (CT), and Ultrasound (US) triggers the need for efficient techniques to transport and store the related volumetric data. ROI has emerged as a prominent approach that predominately decreases the volume of medical images, a context and ROI based approach is introduced. This approach facilitates for coding the ROI with better quality than the rest of the image. The methodology incorporated in this paper for ROI based compression using the WT and other encoding techniques is as mentioned in Figure1.

ROI separation

Automatic extraction of ROIs in medical image is of research interest in medical image processing. It uses the gray features of the medical image, in order to extract ROIs of medical. However, there are variety of features associated with medical images which this ROI extraction method a cumbersome task. Manual selection of the ROI is performed in order to overcome these effects. Once ROIs are specified, the location of ROIs is recorded. If there are N-1 ROIs and one background area then, the ROIs encoding process takes different priorities which specifies the significance of it. The high priority means bit stream generated for this ROI will be appeared early in the whole image bit stream.

Image data separation

After ROIs determination, the image is separated into ROIs and non-ROIs. Non-ROIs are processed by wavelet transform first since coefficient matrix is required to be input of encoder. The processed coefficients are sent to ISPIHT encoder.

Image compression

After the separation of image data, the coefficient matrix of image data is sent to SPIHT and get the corresponding bit streams.

Bit stream integration

After the process of above steps, integrate all bit streams, which include SPIHT bit stream and edge information made by canny operator.

Encoding using SPIHT and EZW

SPIHT

After WT decomposition the coefficients of the decomposed image have to be coded considering the inherent redundancy and the storage limit. SPIHT emerged as one of the significant techniques which gained importance with its efficiency and performance exceeding the then existing techniques. The technique is unique with the feature of zero trees which refers to the spatial distribution of the trees. It incorporates a method that takes bounds between coefficients through sub-bands in different levels. SPIHT deals with three lists namely List of Significant Pixels (LSP), List of Insignificant Pixels (LIP) and List of Insignificant Sets (LIS). These lists are referred as location lists of their co-ordinates. This step is followed by framing a bit-stream. This is possible with the two level thresholding known as

- Sorting pass - where the lists are arranged following a specific rule
- Refinement pass - which does the actual progressive coding transmission.
The algorithm furnished with several advantages. One being intensive progressive capability and its one bit based reconstruction process. This enables the compressed to get accessed even on slow networks. The other advantage is that it provides a very compact output bit-stream with large bit variability. As a result there is no requirement of additional entropy coding. It is also possible to insert a watermarking scheme into the SPIHT coding with strong invisibility and attack resiliency. However, there are some disadvantages associated with this approach. It is highly vulnerable to bit corruption, as a single bit error can introduce relevant image distortion.

**Embedded zerotree wavelet algorithm (ezw)**

The role of Image segmentation in the current work is to distinguish the ROI from the background data which is considered as non-ROI. Lossy compression technique like EZW is employed to compress non-ROI while the compression of ROI is performed using lossless compression like HAAR. The EZW algorithm incorporates different principles of DWT like hierarchical-sub-band-decomposition. The technique predicts and discards information which has self-similarity of non-vital information which is present in images. It considers Entropy-coded successive-approximation quantization. Instead of sign or magnitude, the technique uses location as it is considered that the location has better correlation than the former. Later, mapping is performed with model like $|X| > \text{th}$. Every wavelet coefficient is mapped to certain coefficient in the next incremented level. ZT which is referred to the "zero valued" maps to the other zero levels in the incremented scale. With the specification of ZT it is a practice to track down and replace with zero.

**Results and Discussion**

Results pertaining to the above discussion are given in this Section. As discussed above the entire simulation based experimentation is divided in to three cases. In all the three cases the HWT is used as the decomposition technique while the encoding method is varied for each case. The entire simulation is carried in MATLAB environment and run on System with specifications - dual core, 2GB RAM. The popular SPIHT is applied as a lossy compression technique for the non-ROI region while the HWT is used for compressing the ROI which enables a lossless compression. The input image is as shown in Figure 2(a). The ROI is identified using the embedded marking tool in the MATLAB environment. This is followed by the processes of separation of ROI from the region surrounding it. The resultant isolated ROI is as show in Figure 2(b) and the corresponding non-ROI is as shown in Figure 2(c). The proposed lossless compression is applied to the ROI and the lossy compression equipped with SPIH is performed on the non-ROI. The resultant compressed non-ROI and ROI are given Figure 2(d) and Figure 2(e). Later, the two compressed images are fused and presented as shown in Figure 2(f). Similar to the above case, the lossy compression technique in the second case is EZW. In order to comprehend the advantages and the performance of the SPIHT and EZW encoding in ROI based compression of medical images, a suitable standard encoding technique known as global threshold is applied finally to the same image for which the above mentioned two schemes are applied. Finally the resultant image metrics like MSE and

![Select the ROI](image1.png)

![ROI image](image2.png)

![Original image](image3.png)

![Compressed image](image4.png)

![Compressed ROI](image5.png)

![Fused compressed image](image6.png)

**Table 1 — Calculated MSE and PSNR for all cases**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Description</th>
<th>MSE</th>
<th>PSNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SPIHT HAAR</td>
<td>2.0356</td>
<td>90.0114</td>
</tr>
<tr>
<td>2</td>
<td>EZW HAAR</td>
<td>2.2702</td>
<td>89.1405</td>
</tr>
<tr>
<td>3</td>
<td>Global Threshold HAAR</td>
<td>5.373e3</td>
<td>21.656</td>
</tr>
</tbody>
</table>

Fig. 2 — Input and output images at every stage in case-1 simulation (a) Input Image, (b) ROI, (c) Original without ROI, (d) Compressed image without ROI, (e) Compressed ROI and (f) Fused compressed image
the corresponding PSNR are measured and tabulated for further analysis in Table.1

Conclusion
A thorough analysis of the three methods in terms of two important statistics of the images known as MSE and PSNR is carried out. The proposed method involving SPIHT and HAAR for separation, compression and further fusion process has shown its efficiency over the other two methods. The global threshold method exhibited the worst performance when compared with that of SPIHT and EZW. However, the performance of EZW is competitively with the proposed SPIHT with HAAR but always appeared to be less than the later.

References