REGION OF INTEREST CODING IN MEDICAL IMAGES USING DIAGNOSTICALLY SIGNIFICANT BITPLANES

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ABSTRACT

Accelerated expansion of healthcare informatics has been inspirational to further innovations in the associated technical areas. Sophisticated diagnostic imaging equipments are generating detailed medical images corresponding to various imaging modalities. These are usually rich in radiological content and the associated file sizes are large. From this data, to identify and extract the region of interest (ROI) relevant to the clinical user with specificity of patient health information is critical to accurate diagnosis. Also the doctors prefer image-processing solutions that have the scope for integrated, interactive and subjective evaluation of radiological information. Based on these observations, a method to code ROI by prioritized combination of diagnostically significant bitplanes has been presented. This method has applications in the areas of image compression, storage, retrieval and structured reporting of medical data.

Keywords: *Medical Image Processing, Region of Interest (ROI), Diagnostically Significant Bitplanes (DSBs)*

1. INTRODUCTION

Research in diagnostic imaging and image processing is gaining prominence all over the world, particularly in developing countries like India [14]. Engineers are developing technologies and tools, enabling the medical practitioners to provide efficient treatment. From the elaborate medical information, the doctor prefers to focus on certain selected region(s) of interest. Also the doctors are more comfortable with image-processing and analysis solutions that offer subjective analysis of medical images more than depending on the objective engineering results alone. Technology assisted, integrated diagnostic methods are of high relevance in this context [9].

2. TECHNICAL DISCUSSION

In the medical scenario, the region of interest (ROI) is the area(s) of an image, which is of clinical/diagnostic importance to the doctor [11]. Certain image specific features like the uniformity of texture, color, intensity etc. generally characterize region of interest.

Medical images are mostly in gray scale [12]. The gray scales of an M-bit level image (where M can be 8, 12 or 16 bits) can be represented in the form of bitplanes as in the Fig.1 below.

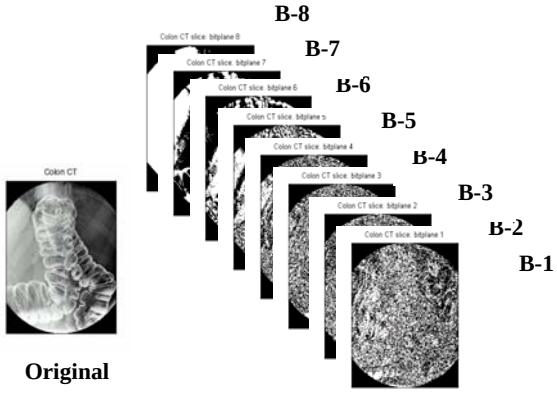

Fig.1. Colon CT Image and its eight bitplanes

2.1. Identifying ROI

Identifying and extracting the region of interest accurately is very important before coding and compressing the image data for efficient transmission or storage.

2.2. Loss-less, Lossy and Regionally Loss-less

Coding algorithms used in various applications are derived based on the standard image compression schemes [16]. These are lossy or lossless based on the end user need.

Totally lossy schemes result in image alteration, which might entail loss of diagnostic or scientific utility. On the other hand completely lossless schemes are expensive in low-band width situations like tele-radiology.

Based on the detail in different spatial regions and identifying the region of interest of the image it is possible to compress different levels of reconstruction quality. This way one could accurately preserve the features needed for medical diagnosis or for scientific measurement, while achieving high compression overall by allowing degradation of data in the unimportant regions.

2.3. Diagnostically Lossless Schemes

In medical context the regionally lossless schemes have to be studied more closely. They can be any of the following based on different types of end user/observer or context.

- "Visually lossless" (non-clinical human observer)
- "Diagnostically lossless" (clinical-observers) Significant degrees of inter-observer and intra-observer variations may be there.
- "Quantifiably lossless" (mostly non-human observer/ computer assisted detection)

What may be visually lossless or quantifiably lossless may not be diagnostically lossless, may be information consideration our method is proposed [9,11,12]

2.4. Coding Scheme

Most of the commonly used methods use baseline JPEG-2000 algorithm that involves the following important steps [3]. Along with these mentioned below, additional processing related to ROI mask generation and customized coding that suits the user requirement is done.

1. Color transform is performed on the tiles or the entire image based on size of the image
2. On this discrete wavelet transform is calculated as in JPEG-2000 [10].
3. If the ROI is identified, then an ROI mask is derived extracting the region, indicating the set of coefficients that are required for lossless ROI reconstruction.
4. The wavelet coefficients are quantized as per the quality of reconstruction needed. These coefficients are stored in a sign magnitude representation. Magnitude bits comprise the most significant part of the implementation precision used.
5. The coefficients that are out of the ROI are scaled up/down by a specific scaling value. If there are more than one ROI, these can be multiply coded with different scaling values.
6. The resulting coefficients are progressively entropy encoded (with the most significant bit planes first). As overhead information, the scaling value assigned to the ROI and the coordinates of the ROI are added to the bit stream. The decoder performs also the ROI mask generation but scales up the background coefficients in order to recreate the original coefficients.

Also in medical situations during compression phase, lossy schemes are not preferred. This is to avoid the chance of loosing any diagnostically significant data.

Lossless schemes prove costly with less compression efficiencies and are ineffective in certain application environments [14].

Regionally lossless schemes [3] prove as a valuable/meaningful solution between the completely lossless or lossy ones. In these lossless coding is done for the ROI(s) and lossy coding to the less significant background image [13].

3. OUR APPROACH

3.1. Some Observations

We develop our approach based on the following observations.

- The doctor prefers to use the eyes/subjective decision more to arrive at the region that is of importance to them through interactive evaluation and use the mouse clicks to mark regions [9,11].
- The pixels that represent the diagnostically relevant data are of interest to the doctors. These bits need not belong to visually significant data [12].

Bitplane-slicing methods [5] decompose the image into a series of binary images. Bit-plane slicing is helpful more

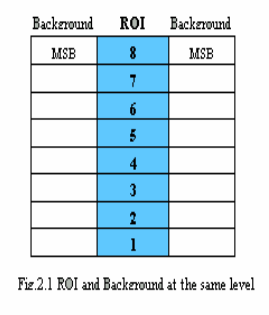

Fig.2.1 ROI and Background at the same level

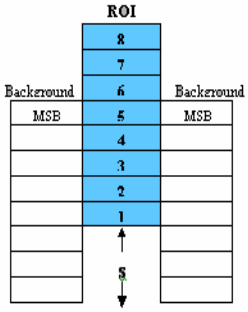

Fig.2.2 Generic Scaling method

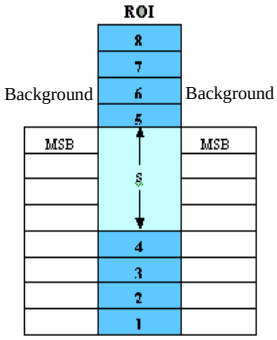

Fig.2.4 MSB Shift method

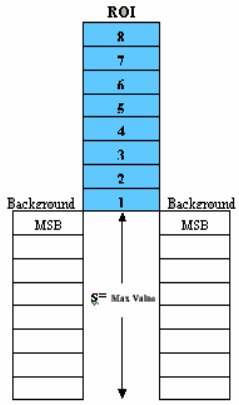

Fig.2.3 Max Shift method

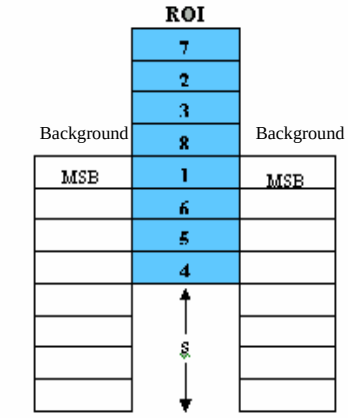

Fig.2.5 Proposed method

Fig.2. The region of interest and background bitplanes represented using different methods.

In the Fig.2.5 we notice that, while other methods use the scale to shift the bitplanes corresponding to ROI, our scheme suggests an improvisation over these. DSBs are identified and coded in order of priority.

In analyzing the relative importance played by each bit of the image.

3.2. Existing Methods

Existing Methods [4,6] like the Generic Scaling Method (Fig 2.2), Maxshift method (Fig 2.3), MSBshift Methods (Fig 2.4), the coefficients of region of interest are shifted as shown in Fig.2 by certain scale factor, **s**. This is done during the encoding of the image after performing the discrete wavelet transform [1,7] and quantization.

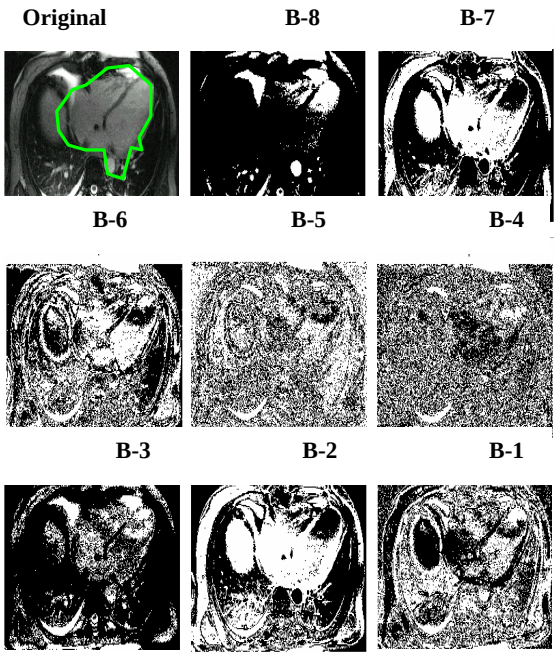

Fig.3. B-{8,1} are bitplanes of heart

In Fig.3, heart region is the region of interest. We notice that priority of the bitplanes with the ROI better diagnosed is {7,2,3,8,1,6,5,4} i.e. 7th bitplane has better ROI content than 8th bitplane etc.. The DSBs can be organized in priority before coding ROI using any of the existing methods. Decoding of the ROI is performed in the order of DSBs.

3.3. Proposed Method

Based on the previous section, we notice that the diagnostically significant ROI data is not necessarily contained in the MSBs, but can be in any of the bitplanes in any order. This can be observed in Fig.3, Fig.4 and Fig .5. The clinical observer can decide the priority of these bitplanes and we call these as diagnostically significant bitplanes (DSBs).

- Clinical Observer/lab technician/the person at the encoding end can identify the region of interest to the diagnostic context with the help of the doctor.
- Then the bitplanes that have significant information associated with this ROI are identified and prioritized in the order of significant information as DSBs.
- During entropy coding phase these DSBs are coded in the order of priority
- At the decoding end, the priority bitplanes are decoded first and the user can stop to decode

4. ADVANTAGES

Our approach has the following advantages .

- The proposed method reduces the speed of transmission as the DSBs can be decoded first and the clinical observer can choose to stop any time [1].
- It offers more flexibility as the user can choose to decode all the bitplanes if needed for complete data.
- There are medical cases in neuro-imaging where two images [12], which look alike, may belong to two different diseases. Bitplane by bitplane study may also open up doors to reveal the data that so far looked hidden anatomically. This may result in more accurate diagnostics, Fig.5.
- **Applications**

  This method is primarily aimed at helping the doctors. This method of ROI extraction and coding has many applications not only in diagnostics, but also crucial for efficient transmission, compression rates, picture archiving and communication systems (PACS) more pronounced role to enhance structured reporting in DICOM [15].

5.CONCLUSIONS

This paper introduces the concept of DSBs that can help in more accurate identification of ROIs and disease zones.

It suggests a method for ROI coding in the order of DSBs as an improvisation over the existing methods with an empathetic understanding to image analysis from a diagnostic perspective.

6. FUTURE WORK

DSBs can be combined with quantifiably lossless schemes for providing integrated diagnostic expert solutions [8].

Compression efficiency and coding complexity can be comparatively studied to Generic Scaling in order of MSBs vs DSBs [6]. This may lead to modifications of JPEG-2000 and associated ROI coding in DICOM [I1].

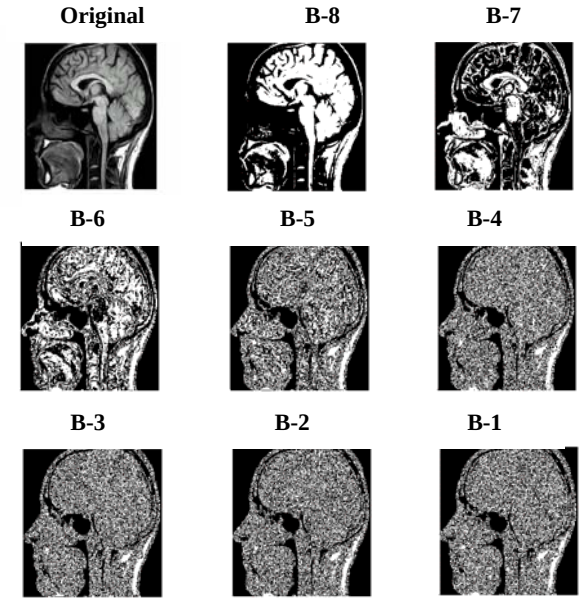

Fig.4. Head-MRI image original and its bitplanes. Based on the diagnostic priority bitplanes 7, 6,8 may have more relevant info in the brain region, while in the eye region 4,5,2 have more accurate info.

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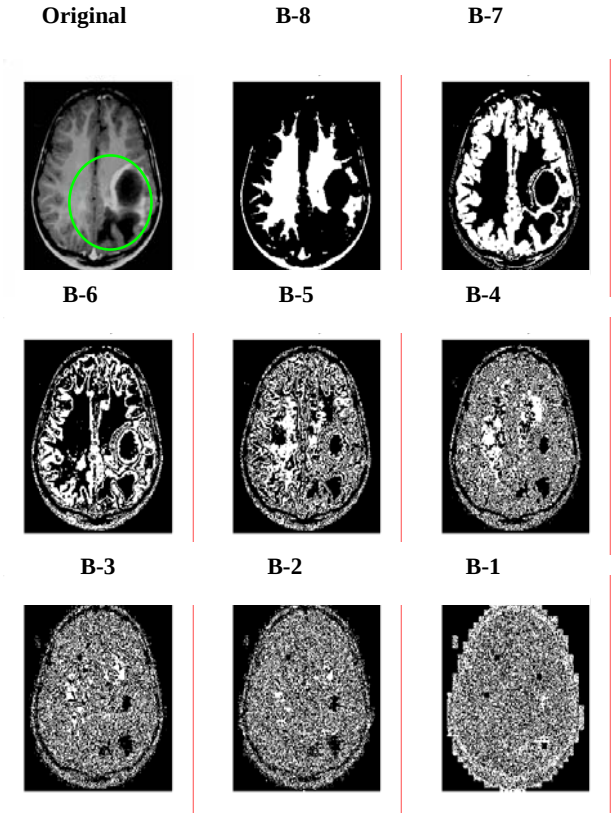

Fig.5. B-{1,8} are the bitplanes of brain slice original. Bitplane 7 gives more accurate view of the tumor region than bitplane 8. Lower bitplanes pin the infected zone down the origins to more accuracy.

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