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JPEG 2000 Region of Interest Coding Methods

Jyoti S. Pawadshetty*, Dr.J.W.Bakal**
*(ME (IT)-II, PIIT New Panvel.)
** (Principal, SSJCOE Dombivali.)

Abstract

JPEG 2000 is international standards for image compression and exploiting various features. Region of interest (ROI) coding is one of the extensive features of JPEG2000.JPEG 2000 works as lossy and lossless compression. However it is needed to provide high compression rate with available bandwidth and speed of internet. It would be more appropriate that regions of interest are prioritized for interpretability. JPEG 2000 provides various ROI coding techniques to achieve high quality ROI as compared to Back-ground. Various ROI coding techniques for still image compression are general scaling based method, max-shift method, bitplane-by-bitplane shift method (BbBShift), partial significant bit-plane shift method (PSBShift) and ROITCOP (ROI coding through component priority) method. The choice of methods for ROI coding is very much dependant on the requirements of the application at hand.

Keywords: JPEG2000, ROI, general scaling based method, max-shift method, BbBShift, PSBShift and ROITCOP.

1. Introduction

Region-of-interest (ROI) image coding technique means to compress important regions in a medical image without loss or with little loss, and to compress other regions with much loss. Based on this idea a high compression ratio can be achieved and the important information of ROI part of image can be preserved lossless [1][2],as digital images is having high quality with high compression rate. However there is need to manipulate image data.

The JP2K algorithm is based upon embedded block coding with optimised truncation (EBCOT) [3]. JP2K has been designed to offer compression performance better than, conventional JPEG. JP2K to conventional JPEG [3] indicate approximately an improvement in image quality at the same bit rate with the help of PSNR. The superiority of JP2K is particularly significant at low bit rate.JPEG2000 starts with the adoption of discrete wavelet transform (DWT) instead of the 8 x 8 block based discrete cosine transform (DCT). Rate-distortion is application of JPEG 2000 and it also allows different regions of an image to be coded with different fidelity criteria. During the transmission of image, these regions need to be transmitted first or at a higher priority (for example during progressive transmission) [4].

2. JPEG2000 Image Coding Methods Overview

Image compression requires higher performance as well as new features with the increasing use of multimedia technologies. In the specific area of still image encoding, a new standard is currently being developed for this image compression need , the JPEG2000 [5][6].The JPEG2000 standard was intended to create a new image coding system for different types of still images (bi-level, gray-level, color, multi-component), with different characteristics (natural images, scientific, medical, remote sensing, text, rendered graphics, etc) allowing different imaging models (client server, real-time transmission, image library archival, limited buffer and bandwidth resources, etc) preferably within a unified system.

At the encoder, the discrete transform is first applied on the source image data. The transform coefficients are then quantized and entropy coding is done before forming the output code stream. The decoder is reverse of encoder. The whole image engine has been decomposed into three parts: the preprocessing, core processing and bit-stream, formation parts, although there exists high inter-relation between them. In the preprocessing part the image tiling, the dc-level shifting and the component transformations are included. The core processing part consists of the discrete transform, quantization and entropy coding processes. Finally, the concepts of the precincts, code blocks, layers, and packets are included in the bit-stream formation part. It should be noted here that the basic encoding engine of JPEG2000 is based on EBCOT (Embedded Block Coding with Optimized Truncation of the embedded bit stream) algorithm.

3. JPEG 2000 Region of Interest coding methods

Region of Interest (ROI) coding is a prominent feature of some of the image coding systems. It is aimed to prioritize specific areas of the image through the construction of a code stream that, decoded at increasing bit-rates, recovers the ROI first and with higher quality then rest of the image. In this section, different ROI coding methods are discussed.

Basic Concept: ROI coding [7] methods is gaining importance mainly in medical application mainly in highly diagnostic areas. The highly diagnostic area in medical images is called Region of interest (ROI). In such cases Physicians may not afford any loss of data in ROI. The ROI is encoded with higher quality than background. Transformation based coding is applied on image; which include Discrete wavelet transform (DWT) and Discrete Cosine transform. DWT is applied on image to find out wavelet coefficients. These coefficients related to ROI are transferred at higher priority as compared to background coefficients. To reconstruct image ROI coefficients which are called as ROI mask is introduced, to indicate which coefficients have to be transmitted exactly in order, for the receiver. At the encoder side discrete wavelet transform is applied to the image and coefficients related to ROI are scaled up with specified scaling value, where background coefficients are scaled down.

ROI mask calculation [8]is as follows:

Let R^n be the wavelet domain, $\Omega \in R^n$

$X\,\Omega\,(x)$ is defined as

$$X\,\Omega\,(x) = \begin{cases} 1, & \text{if } x \in \Omega \\ 0, & \text{if else.} \end{cases} \quad (1)$$

Then the ROI mask is generated as

$$gi\ (x) = (\widetilde{W}i\,o\,x\ \ \Omega)(x) + (\tilde{I}i\,x\ \ \Omega)(x) \quad i \in \Lambda \quad (10)$$ (2)

Where $\widetilde{W}i$ is wavelet operatorfor ith sub-band,

Λ is index set of all sub-bands

$\tilde{I}i$ is identity Operator equipped with down-sampling operation.

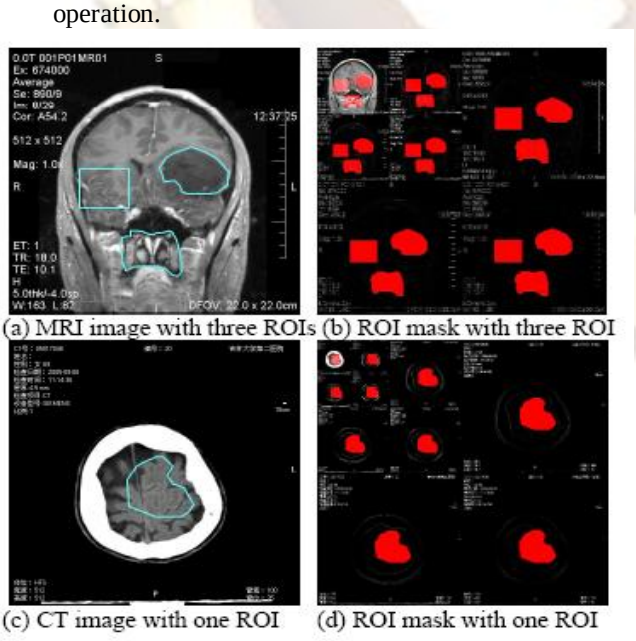

Fig 1: ROI coding techniques used in 2-D still images

3.1 General Scaling based method

The very first method of the ROI coding in JPEG2000 is the scaling method of ROI coding. In General Scaling based method (also defined in Part II of the JPEG2000 Imaging Standard [3][5]) where the bits representing the wavelet coefficients contributing to the ROI region, are shifted upward by a user-defined value [3], so that bits of ROI are placed in higher bit planes than the background. Then during transmission of image bits associated with ROI are placed in the bit stream before transmission of background bits of image. In this method, coefficients of ROI could be coded with non-ROI coefficients. Thus coefficients of ROI are decoded first than the background. Before whole image is encoded, if encoding process is terminated, ROI image quality is higher than the rest of the image. This method allows the use of arbitrary scaling value, so allows fine control on the relative importance between ROI and BG .Further, the general scaling based method requires the generation of an ROI mask and the distinction of ROI/BG coefficients at both encoder and decoder sides. This increases decoder complexity and processing overhead.

The scaling method has two major drawbacks.

1. It needs to encode and transmit the shape information of the ROIs.
2. If arbitrary ROI shapes are desired, the shape coding will consume a large number of bits, which significantly decreases the overall coding efficiency .

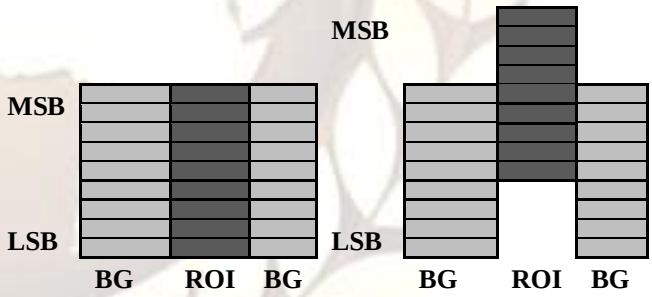

Fig 2a) No Scaling 2b) General Scaling based method, S=4

3.2 MAXSHIFT method

In the max-shift method, the wavelet transform is applied to the original image at the encoder side. Wavelet transform is resulting into sub-band coefficients. Bits not associated with the ROI (i.e. background (BG)) are downshifted below those belonging to the ROI as shown in Fig 3, [6]. A valid up-shift value is a value that ensures no overlap between the ROI and BG bit-planes. To achieve this encoder must select $Rshift \geq \max(Mb)$, where Mb is the largest number of magnitude bit-planes for any background coefficient for sub-

band *b*. In MAXSHIFT method (defined in Part 1 of the JPEG2000 standard), scaled value is computed with arbitrary shape, so that, there is no need to transmit shape information during encoding process. On decoder side, non-ROI coefficients are scaled up to their original bit-planes before the inverse wavelet transform is applied. The downshifting of BG coefficient bits towards the least significant bit-planes isolates ROI bits in the most significant bit-planes.

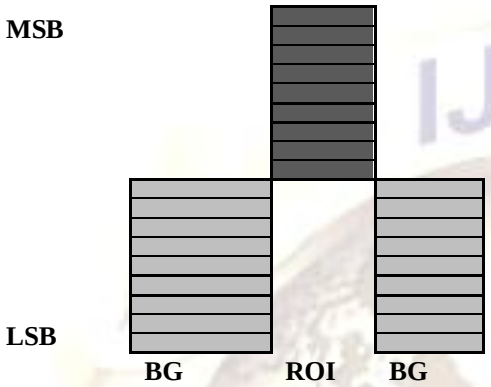

Fig 3: MAXSHIFT method, S=9

3.3 Bit-plane by bit-plane shift coding method

In bitplane-by-bitplane shift (BbBShift) method, it shifts them on a bitplane-by-bitplane basis instead of shifting all bitplanes at once as in MAXSHIFT. An illustration of the BbBShift method is shown in Fig 4[5]. Two parameters, s1 and s2, are used in BbBShift. The sum of s1 and s2 must be equal to the largest number of magnitude bitplanes for any ROI coefficient. At the encoder, for any bitplane of an ROI coefficient If $b \leq s1$, no shift; If $s1 < b \leq s1+s2$, shift it down to bitplane $s1+2(b-s1)$ and any bitplane b of a BG coefficient.
If $b \leq s2$, shift it down to bitplane $s1+2b-1$; If $b > s2$, shift it down to bitplane $s1+s2+b$.The first step at the decoder, for any given nonzero wavelet coefficient, is to identify whether it is an ROI coefficient or a BG coefficient. This can be done by examining the bitplane level of its most significant bit (MSB).
The set of ROI associated bitplanes is given by:

$$Broi = \{b \backslash b \leq s1 \text{ or } b = s1+2k,\ k=1,\ 2...s2\} \quad (3)$$

The BbBShift method supports arbitrary shaped ROI. BbBShift has the flexibility to have an arbitrary scaling value to adjust the relative importance between ROI and BG coefficients with improved quality of ROI coding.

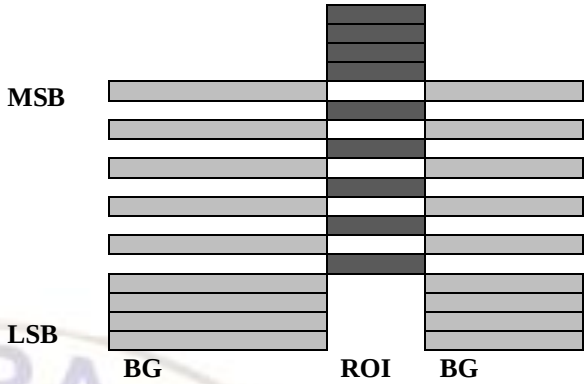

Fig 4.BbBShift methods with S = 4and S= 5(Bitplanes are represented by the gray bars).

3.4 Partial significant bit-planes shift

A new and flexible scaling-based method called *partial significant bitplanes shift* (PSBShift)[6]. PSBShift can combine the advantages of the two standard methods and efficiently compress multiple ROIs with different degrees of interest. This method is mainly based on the facts that at low bit rates, there is need to only shift part of the MSBs of ROI coefficients instead of shifting the whole bitplane as the standard methods do, so it is called as PSBShift. An illustration of the PSBShift method is shown in Fig 5 [10][11] (where s1 = 4 and s2=6).The whole bitplanes of ROI coefficients are divided into two parts: *the MSBs* and *the residual significant bitplanes*.

At the encoder, the MSBs of the residual significant bitplanes of ROI coefficients are down-shifted toward LSB with BG coefficients, while ROI coefficients are not shifted.

At the decoder, ROI coefficients can be identified in the same way as maxshift. The PSBShift method can code ROI in an image with higher or the same quality as BG.

PSBShift JPEG2000 ROI coding method has four primary advantages:
1) It allows different wavelet subbands to have different ROI definitions.
2) It supports arbitrarily shaped ROI coding without coding the shape.
3) It can efficiently code multiple ROIs with different priorities in an image at the low bit rates [12].
4) It can control the relative importance between ROIs and BG by using appropriate scaling values.

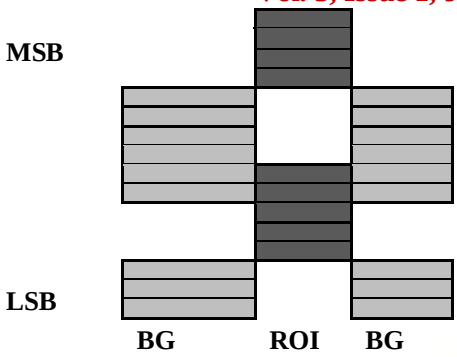

Fig 5 Proposed GPBShiftmethod, *S*1=4, *S*2=6.

3.5 ROI coding through component priority

The JPEG 2000 coding system has to allow the access and manipulation of components in the compressed domain without needing to decompress the image, it is called as component scalability. Multi-component images and component scalability features is provided by ROI coding Through Component Priority (ROITCOP) [12] [13] to allocate each ROI in a component where the non-ROI area is set to zero. These components are prioritized using rate-distortion optimization techniques at desired priorities generating a multi-component image with each ROI prioritized at will.

Before applying ROITCOP, JPEG 2000 encoding system requires two operations which are generate components and join components as shown in fig 6. At the encoder side generate components is that defines as many components as ROIs have the image and one component for background. The operation Join Components sets the magnitude of each ROI coefficient to that recovered at the ROI-component with highest priority containing that ROI coefficient and background coefficient for background coefficient. The key feature of this method is to allocate each ROI in a component and set coefficients of the non-ROI area of that component to zero. However to reduce overall distortion, for multi component images MC-PCRD is applied to combine the bit streams from all component.

The main difference between ROITCOP and previous methods is ROITCOP contain either only ROI coefficients or background coefficients but previous methods contain both type of coefficients. Some advanced features of ROITCOP are: it avoids the dynamic range problem of the decoder; it achieves very high fine-grain accuracy, comparable to that achieved by ROI coding methods based on modifying wavelet coefficients; it enables the definition of multiple ROIs with different degrees of priority; it is able to exclusively recover the desired ROI-simulating the MaxShift method – through the component scalability; it is able to decode the ROI and the background in a lossy-to-lossless mode;

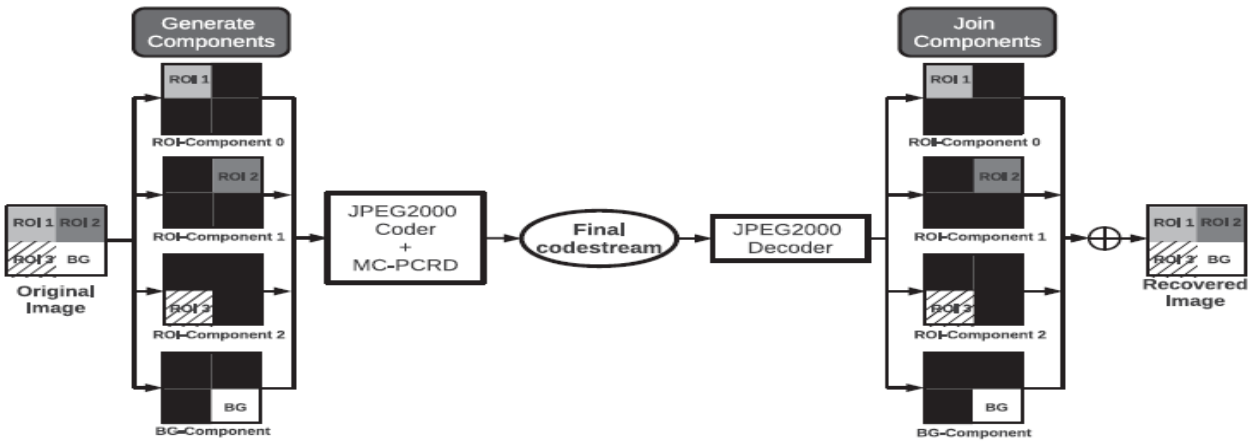

Fig 6. Show Operations for the ROI coding method. Two operations are added in coder/decoder pipeline: generate components and join components

Conclusion

We have provided overview of JPEG2000 compression method with enhanced ROI coding methods which are useful to find out highly diagnostic area called as ROI and apply high compression rate on other part.JPEG 2000 performs for lossy and lossless compression with most effective DWT tool. ROI coding techniques are enabling better image examination and addressing issues regarding image handling and transmission in telemedicine systems. Thus medical image compression with ROI coding techniques are gaining importance mainly in medical areas. These techniques enable their use in internet and mobile phones. With available bandwidth and power, ROI coding techniques transmit image data from one location to other location and support the moving

and commuting physicians. Thus JPEG2000 ROI coding techniques plays an important role in medical image compression.

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