Multiple Region of Interest Coding using *Maxshift* Method

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Abstract: Image data processing on the region of interest (ROI) for providing the primary information is needed the view of saving search time and bandwidth over image communications related to web browsing, image database, and telemedicine, etc. Hence, the issue on extracting the region of interest is drawing a plenty of attention for the communication environment with a relatively low bandwidth such as mobile internet. In this paper, we propose a improved standard *Maxshfit* method. The proposed algorithm compress image that includes multiple ROI using *Maxshift* method in Part 1 of JPEG2000. Simulation results show that proposed method increases PSNR vs. compression ratio performance above the *Maxshift* method.

Image Compression, Multiple ROI, *Maxshift* Method, ROI, JPEG2000 Part 1

1. INTRODUCTION

Recently, Part 1 of JPEG2000 adopted a coding technique called *Maxshift* method that effectively handles the region of interest.[1,2] By applying the *Maxshift* method to the image data containing the region of interest, the coded coefficients belonging to the region of interest are placed in the bit plane above the planes containing the biggest coefficients representing background.

This method can show only the ROI area in the given image to the user from consecutive transmission using the embedded coding of coefficients in ROI. Also, ROI coding provides a much better quality of image than non-ROI area from the use of lossless compression technology.[3]

But it has a disadvantage in the *Maxshift* method. It is that image has only one ROI.

Therefore, in this paper, an improved algorithm for processing image data that involves one or more region of interest is presented in order to increase the PSNR vs. compression ratio performance above the previous *Maxshift* method. Call the proposed algorithm *Multiple ROI* method.

This paper is organized as follows. In Section 2, the existing *Maxshift* method of the JPEG2000 Part 1 is introduced. In Section 3, the proposed method is described. The simulation results are reported in Section 4. Finally, In Section 5, the conclusions are represented.

2. THE *MAXSHIFT* METHOD

2.1. ROI coding

In Some applications, it might be desirable to encode certain portions of the image (called the region of interest or ROI) at a higher level of quality relative to the rest of the image (called the background). Alternatively, one might want to prioritize the compressed data corresponding to the ROI relative to the background so that it appears earlier in the code stream. This feature is desirable in progressive transmission in case of early termination of the code stream.

ROI coding can be accomplished by encoding the quantized wavelet coefficients corresponding to the RCI with a higher precision relative to the background, e.g., by scaling up the ROI coefficients or scaling down the background coefficients.[4]

An image with ROI can be transmitted progressively with a user-specified interest area, hence the compression rate and transmission time show a better performance than simple progressive transmission methods. Furthermore, it can support the user's various needs such as efficient memory management. The Part 1 of JPEG2000 recommends the *Maxshift* method for ROI coding, which is covered in the following sub-section.[5]

2.2. *Maxshift* method

The *Maxshift* method finds the largest coefficient in the background area and places the interest area in a higher bit-plane than the largest coefficient from the backgrourd area. This encoding method keeps the coding efficiency with limited number of bits by keeping the value of the largest coefficient in the background area instead of the information on the shape itself. There is one disadvantage with this encoding method that the coefficients of the background area cannot be obtained until the decoding of the interest area and that there is only one interest area. In such ROI coding, ROI mask needs to be generated first to select the interest area. This ROI mask should be in wavelet transformation form, since the image to code is wavelet transformed. ROI mask transformation can be given as below.

$$M(x,y)=\begin{cases}1, & \textit{inside ROI}\\ 0, & \textit{Background ROI}\end{cases} \qquad (1)$$

Here, *M(x,y)* means the coordinates of each pixel in the input image and is 1 when within ROI and 0 when in background. Inside a encoder, the coefficients outside the ROI are adjusted to be on a higher bit-plane than those inside the ROI. The scaling value s used in this process is as given below.

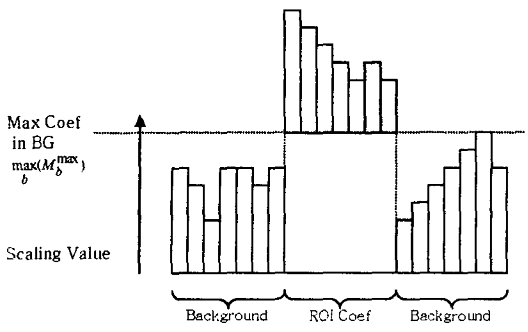

Fig. 1. Scaling of ROI coefficients

$$s \geq \max_{b}(M_b) \qquad (2)$$

M_b in equation (2) means the largest coefficient in the background area after quantization. This also means that after scaling all coefficients in ROI should be bigger than those in non-ROI. Therefore all coefficients in ROI are located on a higher bit-plane than those in background area.

Fig. 1 illustrates the method to find the biggest background coefficient to obtain the scaling value s and to scale up ROI coefficients the biggest background coefficient to obtain the scaling value s. This insures that the smallest nonzero ROI coefficient is still larger than the largest background coefficient as shown in Fig. 1.

ROI coding using the *Maxshift* method supports coding of ROI of any arbitrary shape without a need to send information on the shape of ROI. When reconstructing the image without any information on the shape of ROI, the decoder can perform a scale-down since it knows that the coefficients are scaled up in the higher bit-plane than the scaling value s.

3. PROPOSED *MULTIPLE ROI* CODING

Let us consider an example of 2 ROI in *Maxshfit* algorithm. When there are two ROI, (A) and (B) as shown in Fig. 2, the standard ROI algorithm needs to specify the start point x of (A) and the end point of (B) which includes both (A) and (B) to generate the mask value for both ROI, as if there is one large ROI.

While the need for coding of ROI (A) and (B) can be justified since each of them takes up only 10% ~ 20% of the entire image, the coding of both ROI, from (A) to (B) is not as effective due to its area occupying almost 60% of the image. In an extreme case of ROI starting at the beginning of the image and ending at the finishing of the image, the ROI covers the entire image. Hence, there is no real difference from simply transmitting the entire image.

Therefore, this paper processes ROI (A) and (B) separately using the characters of the coordinate system and achieves a more efficient image coding on ROI with different priorities. To select masks for both ROI, (A) is selected in a conventional way and the location and the size of (B) are obtained using the information on coordinates of the start and the end of the area (A).

Also Fig. 2 shows the start and the end of the ROI (B) with consideration of production of x- and y- coordinates of

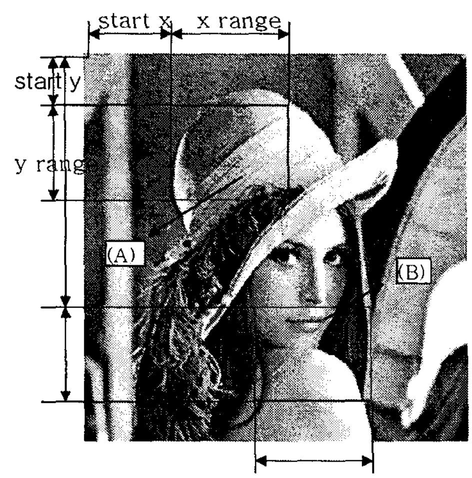

Fig. 2. The proposed *Multiple ROI* masks

ROI (A). The mask transformation given in equation (1) is used to perform ROI mask coding regardless of ROI (A) and (B), which is used in the *Maxshift* method in Part 1 of JPEG2000.

After wavelet transformation and quantization using the generated mask, ROI is distinguished from the background area. The biggest coefficient value in the background area gets calculated to distinguish the areas, as given in equation (2).

The variable s in equation (2) is used to scale up the first ROI using the *Maxshift* method. This value s is called the scaling variable and used to distinguish ROI from the background region. The equation (3) is used to find the biggest value in the first ROI M_{r1}, in order to determine the priority between two ROI this paper proposes.

$$p = \max_{M_{r1}}(M_{r1}) \qquad (3)$$

The value p is applied to $s1$ to decide the priority. In other words, the value of $s1$ needs to be smaller than the maximum of p in M_{r1}, or greater than or equal to the minimum of 0, for the second ROI to have a higher priority. The variable $s1$, which is used for scaling up the second ROI, can be 0. This is when the two ROI have the same priority. The equation (4) defines the values on bit planes, where in $0 \leq s1 \leq \max(M_{r1})$.

$$\begin{aligned} M(x,y) &\in M_{r1}(x,y) \qquad s = s \\ M(x,y) &\in M_{r2}(x,y) \qquad s = s + s1 \end{aligned} \qquad (4)$$

Here, M_{r1} and M_{r2} denotes the mask for ROI (A) and ROI (B) respectively. The variable s is the largest value in the background region and $s1$ is the variable to distinguish the priority of M_{r1} and M_{r2}. If $v_b[n]$ denotes the coefficients in background regions after quantization, the values in ROI $M_{r1}(x,y)$ become $v_b[n]+s$ and those in ROI $M_{r2}(x,y)$ become $v_b[n]+s+s1$.

The coefficients, which have been ROI coding after quantization, get compressed in a code-block unit using EBCOT algorithm. As in the standard ROI algorithm, the proposed algorithm does not require the shape information for encoding, which is evident in the bit-plane where the

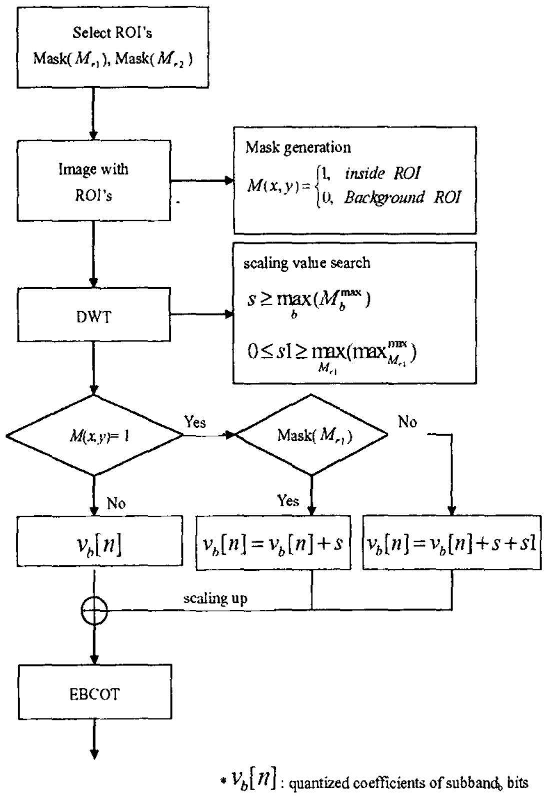

Fig. 3. The flowchart of *Multiple ROI*

Multiple ROI coefficients exist. But at the same time there is a disadvantage of coding non-ROI and it may require more bits to handle the priority between two ROI. In other words, the overall coding overhead increases because the non-ROI coefficients also have to be coded. In an extreme scenario, this may increase the transmission overhead due to the scaling up to the maximum of M_{r1}. Therefore, it is recommended to keep $s1$ less than the value of the largest coefficient in M_{r1} to minimize the transmission overhead while specifying the priority between two ROI. Simulation suggests it is efficient when the value of $s1$ is about 10% ~ 20% of the value of the largest coefficient in M_{r1}.

And Fig. 3 represents the flowchart of the proposed *Multiple ROI* in this paper.

4. SIMULATION RESULTS

512x512 Lena image has been used for simulation. This paper uses RMSE and PNSR for performance evaluation of the proposed *Multiple ROI* method in comparison with the *Maxshift* method under fixed transmission rates of 0.065bpp and 0.125bpp with various wavelet layers.

The RMSE and PSNR values on the image are given in Tables 1 and 2. Fig. 4 and 5 show the PSNR values on the image with 0.065bpp and 0.125bpp respectively. Each Fig. 6 and 7 show the reconstructed images by *Maxshift* method and *Multiple ROI* method under 0.125bpp. The simulation proved that the proposed method showed improvement in performance about 0.0 ~ 0.4dB per 1 ~ 4 layers under low transmission rates of 0.065bpp and 0.125bpp. When all the layers were transmitted, the results were the same.

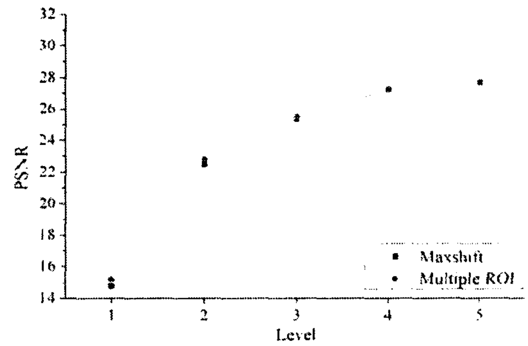

Fig. 4. The PSNR in 0.065bpp

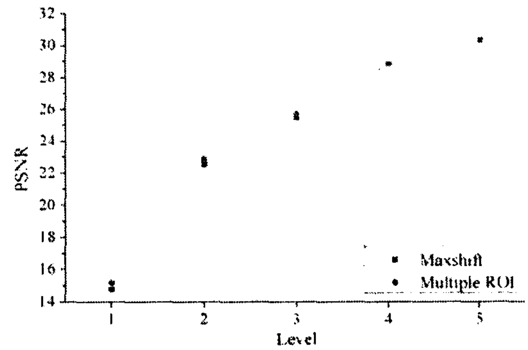

Fig. 5. The PSNR in 0.125bpp

Table 1. The RMSE in 0.065

	Method	Wavelet layer			
		1	2	3	4
RMSE	Maxshift	2183.155	365.0080	190.1037	122.5536
	Multiple RO	1987.122	341.5310	183.4102	122.5536

Table 2. The RMSE in 0.125

	Method	Wavelet layer			
		1	2	3	4
RMSE	Maxshift	2182.532	364.2563	183.4258	88.8799
	Multiple RO	1986.009	338.8219	175.846	85.4104

5. CONCLUSIONS

This paper proposed a *Multiple ROI* coding method to support more than one interest area in an image, using the *Maxshift* method in Part 1 of JPEG2000. Standard image such as Lena has been used for simulation and performance evaluation.

The proposed coding method, as a result of simulation, has the characteristics as bellow.

- It can support one or more ROI per user requires. Therefore the ROI coefficients are received before the background.
- It is possible to compress, transmit and reconstruct the image data with a better quality than the *Maxshift* method in the lower transmission rate.

- It saves a search time on the communication environment with a relatively low bandwidth such as mobile internet.

This coding method can be utilized for applications that require no loss of a particular image area such as biomedical image, that require a fast transmission of a particular image area, or on the communication media with low-bandwidth.

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Fig. 6. The Reconstruction image by *Maxhift*

Fig. 7. The Reconstruction image by *Multiple ROI*