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ภาคผนวก

ภาพทดสอบ

รูป ก. F16 ขนาด 512x512 จุดภาพ 24 บิตต่อจุดภาพ 75% จากขนาดจริง

รูป ข. Butterfly ขนาด 554x366 จุดภาพ 24 บิตต่อจุดภาพ 75%จากขนาดจริง

รูป ค. News ขนาด CIF 352x288 จุดภาพ 24 บิตต่อจุดภาพ เท่าขนาดจริง

บทความทางวิชาการที่ได้รับการเผยแพร่

1. ได้รับการตอบรับงานประชุมวิชาการทางวิศวกรรมไฟฟ้าจาก IEEE International Workshop on Nonliear Signal and Image Processing (NSIP 2005) สำหรับบทความ "Improved Multiple Region of Interest Coding for JPEG2000" ในระหว่างวันที่ 18-21 พฤษภาคม 2548

Improved Multiple Regions of Interest Coding for JPEG2000

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Abstract*— Normally, image data have an important detail only in some regions. One feature of JPEG2000 still image coding is the ability to code region of interest (ROI) with higher quality. The standard defines two methods for ROI coding, generic shift and maximum bitplane shift (Maxshift). Generic shift can select the scaling value of ROI, but the shape needs to be sent to decoder whereas Maxshift does not need to. However, Maxshift does not allow the selection of scaling value to define the relative importance between ROI and background (BG) coefficients. Later BbB shift and GBbB shift were proposed. These two methods can select the scaling value without the need to send shape information, but these two methods are not applicable for multiple ROIs coding. Lately, the partial significant bitplane (PSB) shift was proposed. It offers different degrees of interest and also supports multiple ROIs coding. However, PSB shift sacrifices some qualities of ROI region in exchange of the improved quality of BG region. To some extent, it causes the ROI region to be coded at lesser quality than that of BG. In this paper, we analyze the advantages and disadvantages of each method and propose the use of PSB Shift in conjunction with Maxshift scheme to achieve the better quality in ROI with the ability to adjust degree of interest relative to their importance.

Keywords: JPEG2000, Region of Interest coding, PSB shift, Maxshift.

I. INTRODUCTION

Region of Interest (ROI) image coding is a new JPEG2000 [1] feature which allows ROI to be coded with better quality than the rest of the image. It is done by arranging the stored or transmitted data relative to important regions. The overall JPEG2000 coding process has 3 steps; transformation, quantization and arithmetic coding. In the arithmetic coding, JPEG2000 encodes the coefficients in order of bitplane as shown in Fig. 1(a), from most significant bit (MSB) to least significant bit (LSB). After the transformation process, the coefficients are partitioned into subband then code-block. Coefficients in each code-block which lie in the same position in each subband can be reconstructed to the image at that relative area with the image. To code the image with ROI, it is done by shifting the coefficients in bitplane before passing it to arithmetic coding. In the JPEG2000 standard there are two kinds of bitplane shift schemes, Maxshift [2], and the generic shift [3]. Also there are three works related to ROI coding that use bitplane shift scheme in JPEG2000, bitplane by bitplane shift (BbB) [4], generalized bitplane by bitplane shift (GBbB) [5], and partial significant bitplane shift (PSB) [6]. All bitplane shift schemes are dissimilar in the way coefficients

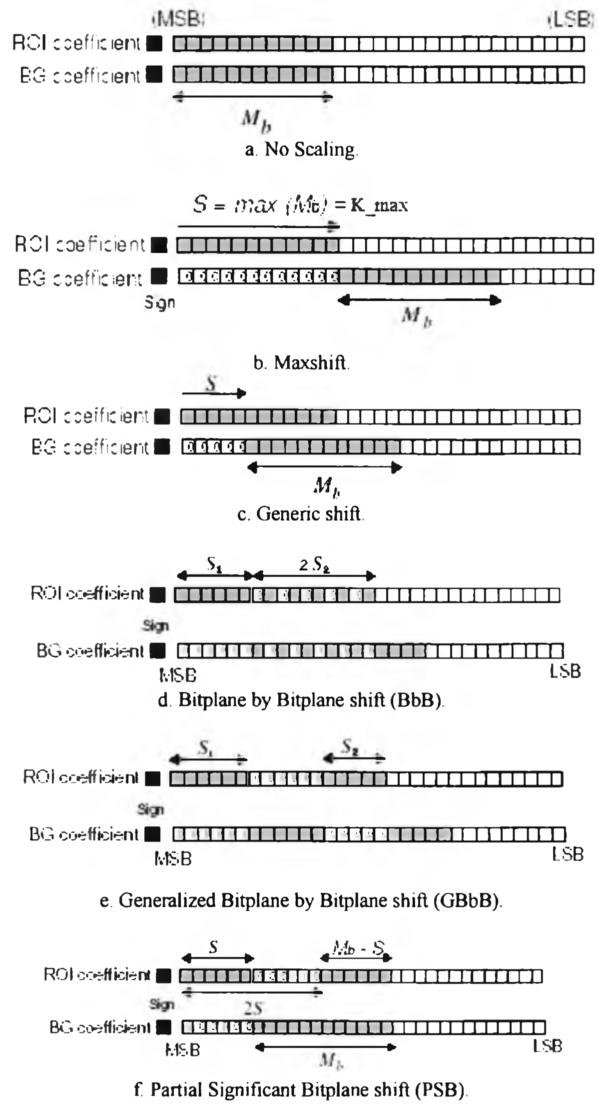


Fig. 1. Bitplane shift schemes [2-6].

are shifted, as shown in Fig. 1(a)-1(f). Note that the notation M_b is the number of bitplane in a code-block b, K_max is the maximum number of bitplane and s is the scaling value.

A. Maxshift

The BG coefficients are scaled down equal to K_max, as shown in Fig. 1(b). The coefficients that belong to BG must be shifted down by s bitplanes such that BG and ROI bitplanes do not overlap, as shown in eq. (1).

$$s = \{s \in Z^+ \mid s \geq \max(M_b)\} \qquad (1)$$

B. Generic shift

The BG coefficients are shifted down by s bitplanes where its value is less than K_max, as shown in eq. (2).

$$s = \{s \in Z^+ \mid s < \max(M_b)\} \qquad (2)$$

C. BbB and GBbB shift

Figs. 1(d)-(e) show BbB and GBbB. Instead of shifting the bitplane all at once by the same scaling value as in Maxshift, the coefficients are shifted on a bitplane by bitplane basis in BbB and/or pack by pack of bitplane in GBbB shift. These two methods have their own shifting algorithm. The BbB and GBbB shift set two scaling values, s_1 and s_2, as shown in eq. (3). These two parameters control relative importance between ROI and BG.

$$s_1 + s_2 = K\_\max \qquad (3)$$

For BbB shift, the coefficients are shifted by the following algorithm.

For any bitplane b of ROI coefficient:

If $b \leq s_1$, then no shift to these bitplanes.

If $s_1 < b \leq s_1 + s_2$, then shift these bitplanes to the bitplane number $s_1 + 2(b - s_1)$.

For any bitplane b of BG coefficient:

If $b \leq s_2$, then shift to bitplane number $s_1 + 2b - 1$.

If $b > s_2$, then shift to bitplane number $s_1 + s_2 + b$.

For GBbB shift, the coefficients are shifted by the following algorithm.

For any bitplane b of ROI coefficient:

If $b \leq s_1$, then no shift to these bitplanes.

If $s_1 < b \leq s_1 + s_2$, then shift these bitplanes to bitplane number $s_1 + b$.

For any bitplane b of BG coefficient:

If $b \leq s_1$, then shift to bitplane number $s_1 + b$.

If $s_1 < b \leq s_1 + s_2$, then shift these bitplanes to bitplane number $s_1 + s_2 + b$.

D. PSB shift

In Fig. 1(f), PSB divides the ROI coefficient into two parts: significant and residual parts At the encoder, the significant part are not shifted, but the coefficients in residual part and BG are shifted by scaling value, s. The residual part has a number of bitplane equal to scaling value and the residual part has the rest of bitplane below s. For PSB shift, the coefficients are shifted by the following algorithm.

For any bitplane b of ROI coefficient:

If $b \leq s$, then no shift to these bitplanes.

If $b > s$, then shift to bitplane number $s + b$.

For all bitplanes b of BG coefficients shift to bitplane number $s + b$

The coefficients in the bitplane are image data in which the image can be reconstructed from these coefficients. However, all bitplane shift schemes change the coefficient value depending upon each method. So, at the decoder side, all of these coefficients have to operate invert shifting to obtain the pre-shifting value.

II. Decoding Process and Limitation of Each Method

Considering the limitation of these ROI coding methods, since the ROI and BG coefficients are shifted differently, the decoder must shift them back properly to decode the image. One major problem in the generic shift method is that the decoder does not know which coefficients belong to ROI or BG region. For rectangular or circle ROI shapes, the encoder needs to send only simple shape information represented by a small number of coordinates. On the other hand, for arbitrary shapes, the encoder has to attach shape information in term of the ROI mask within the bitstream. This makes generic shift not practical for arbitrary ROI shape. The other bitplane shift schemes are otherwise well designed such that the decoded coefficients can check which coefficients belong to ROI or BG without the need to send ROI shape.

For Maxshift, it selects the shifting factor to be sufficiently large such that ROI and BG coefficients can be distinguished. The encoder needs not to send the ROI shape, because the decoder can justify which coefficients are belong to ROI or BG region by checking the first K_max bitplanes. However, the major limitation is that it cannot flexibly assign the relative importance between ROI and BG regions by only adjusting the scaling values because only the decoder have to finish decoding ROI prior to start decoding BG coefficients.

On the other hand, BbB and GBbB methods with more flexible degree of adjusting the scaling values were proposed. However, the coefficients that belong to ROI and BG are different. Thus, the encoder needs not to send the ROI shape because the decoder can generate the mask from parameters and check which coefficients belong to ROI or BG itself. Nevertheless, these two methods are not practical for coding the image with multiple ROIs. If multiple ROIs are defined then coefficients that belong to each ROI must be mapped onto different bitplane numbers, leads to the large number of bitplane.

For PSB shift, it also designs with flexibility in adjusting the scaling values to control the degree of interest in image. Moreover, it supports multiple ROIs with different degrees of interest. At the decoder, ROI coefficients can be identified in the same way as Maxshift. All bits lower than the s^{th} bitplane are shifted up s bitplanes, and are combined with the bits higher than the s^{th} bitplane. It is a little different from the Maxshift decoding method, in which no combination operation is included.

The limitation of PSB shift lies in the case of multiple ROIs coding. For the image with different degree of interest, denoted by ROI-1, ROI-2, and ROI-3, the scaling numbers uses for ROI coefficient are s_1, s_2, and s_3 subsequently. The multiple ROIs are assigned different degree of interest by scaling the different numbers of significant part for different ROIs, as illustrated in Fig. 2.

It can be found that, at the low bit rates, all ROIs have higher quality than BG. ROI-1 has the highest quality while ROI-3 has the lowest quality among three ROIs. When the bit rate increases, the BG quality increases quickly. In some cases, the quality may be better than the quality of ROI-3 and even better than ROI-2. This is because the scaling numbers of the significant part of ROI-3 and ROI-2 are not large enough.

III. THE PROPOSED BITPLANE SHIFT SCHEME

The objective of this work is to develop the JPEG2000 ROI which can code multiple ROIs, have an ability to adjust the relative importance between ROI and BG, and also maintains better quality for different ROIs.

At the beginning, JPEG2000 uses the discrete wavelet filter bank to transform the image data into low and high frequency subband, as shown in Fig. 3. If the image is coded with ROI, the region that defined by user will be mapped onto each subband. The wavelet recursive decomposition is the pyramid decomposition [7]. The proposed method integrates Maxshift and PSB shift. PSB shift is applied to some subbands for flexibility in adjusting the scaling value while Maxshift will also applied to the other subbands to fully scale ROI regions. Next, each subband must be decided whether to use PSB shift or Maxshift. Considering after the region mapping process, the regions on the subbands that have lower resolution level have been extended by the lifting structure of wavelet transform. As illustrated in Fig. 3, the shaded region designates ROI region. Note that ROI region in the lower resolution level subband may contain some parts of BG region. Even these two methods are to be used together, the encoder needs not to send shape information since the decoder can check which coefficients belong to ROI or BG regions. In each subband, code-blocks will be assigned to use either PSB shift or Maxshift. Code-blocks from the same subband should be assigned the same bitplane shift scheme. Thus, in our proposed method, we will assign Maxshift scheme to code-block at n^{th} subband resolution level, C^{Bn} and the rest of the code-block will use PSB shift scheme.

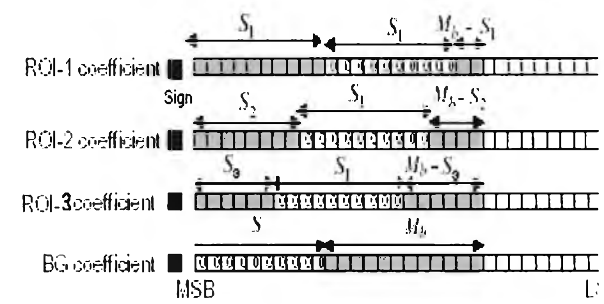


Fig. 2. Multiple ROIs with 3 degrees of interest.

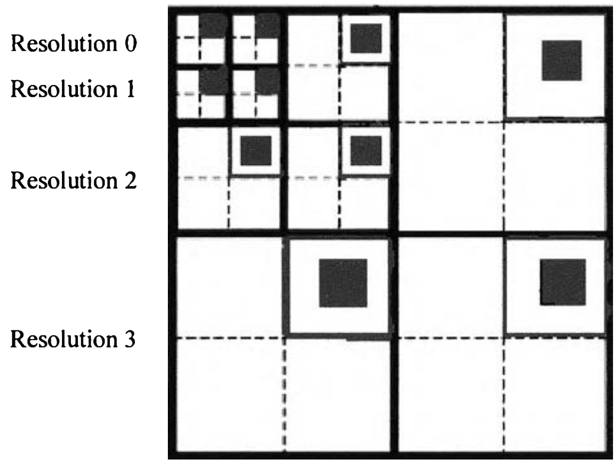


Fig. 3. Wavelet transform image with 3 decomposition Levels with ROI at upper right corner.

Fig. 4. ROI on the test image in the first experiment.

IV. EXPERIMENTAL RESULTS

The first experiment illustrated that the proposed method can support finer degree of interest by setting two parameters, scaling value s, and a code-block from n^{th} subband resolution level C^{Bn} to use Maxshift. Test image sized 554x366 pixels used in this experiment is shown in Fig. 4. The first experiment used 5 levels discrete wavelet transform (DWT) and set ROI region as a circle ROI contained butterfly image. The image is encoded at fixed bit rate of 0.5 bpp. Table 1 shows PSNR (Peak Signal to Noise Ratio) from the method using PSB shift only (first column), and from the proposed method using PSBshift and Maxshift (second to fourth columns) at different scaling values, *s*. For the proposed method, in the second column, we use Maxshift for code-block from subband resolution level 0, C^{B0}, and the rest of the code-block from subband resolution level 1-5 will use PSB shift. Likewise, in the third and fourth columns, we use Maxshift for code-block from subband resolution level 0-1, C^{B0} and C^{B1}, and from subband resolution level 0-2, C^{B0}, C^{B1}, and C^{B2}, respectively. Simulation results indicate using our proposed method could enhance the quality of ROI region that using PSB shift only.

TABLE I
PSNR FROM THE FIRST EXPERIMENT

Scaling value	PSB	The proposed method		
		PSB and Maxshift at C^{B0}	PSB and Maxshift at C^{B0} and C^{B1}	PSB and Maxshift at C^{B0}, C^{B1} and C^{B2}
1	16.34	16.89	17.14	18.71
2	16.34	16.90	17.13	18.43
3	16.29	16.82	17.10	18.38
4	16.96	16.96	17.10	18.46
5	18.98	18.98	19.24	19.98
6	21.39	21.41	21.82	23.40
7	23.80	24.15	25.15	26.33
8	25.57	26.89	26.75	26.80

Fig. 5. Test image in the second experiment with multiple ROIs

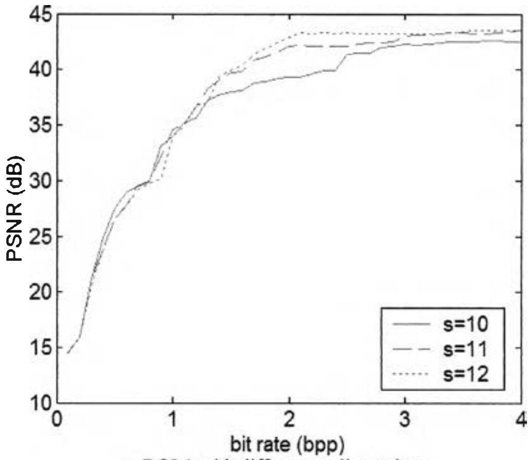
The second experiment illustrates that the proposed method provide higher PSNR to the image that has several ROI regions at high and moderate compression ratios. Test image used in this experiment is News, as shown in Fig. 5. We assign 3 ROI regions: the first ROI denoted by ROI-1 is a rectangle on the text "MPEG4 WORLD" at the lower left corner, the second ROI denoted by ROI-2 is a circle on a woman face, and the last ROI denoted by ROI-3 is a circle on the man face. Note that we define the importance of ROI-1 > ROI-2 > ROI-3, i.e., ROI-1 has higher degree of interest than ROI-2 and ROI-3, respectively. This experiment uses PSB shift to subbands resolution level less than 3 and uses Maxshift to the subbands resolution level greater than and equal to 3. The varied parameters that use to control the quality of degree of interest are scaling value s_1, s_2 and s_3.

The results are plotted in Fig. 6. The proposed method can control the quality of degree of interest by adjusting the scaling values and subband resolution level to be coded with Maxshift. The selected scaling values are $s_1, s_2, s_3 =$ 10, 11, 12. Note that the K_max value is 14 and $s_1 - 2 = s_2 = s_3 + 2$ and $s = s_1$. Thus, there are differences in quality in ROI-1, ROI-2 and ROI-3, i.e., the proposed method can assign relative quality in different degree of interest among several ROI regions in a single image.

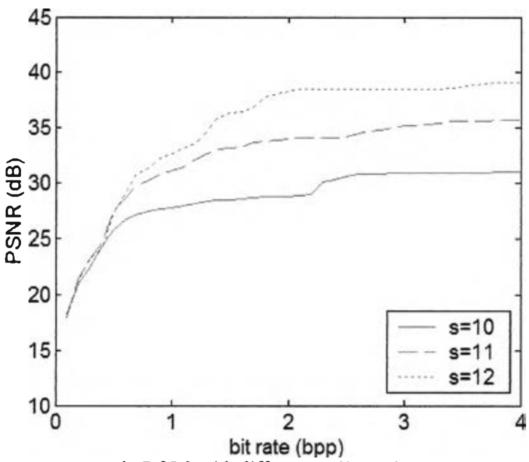
Fig. 7 shows the comparison between the proposed method and PSB shift. Using PSB shift results in lower PSNR of the ROIs which have lower degree of interest, for example, ROI-3 or may be ROI-2, at bit rate higher than 1 bpp. The proposed method provides higher quality of ROI images relative to degree of interest of particular ROI than that of PSB shift. The average of PSNR in ROI-3 in the range of bit rate 0.9 to 1.4 bpp is increased around 4.62 dB. The subjective test of the second experiment is illustrated in Fig. 8.

V. CONCLUSIONS

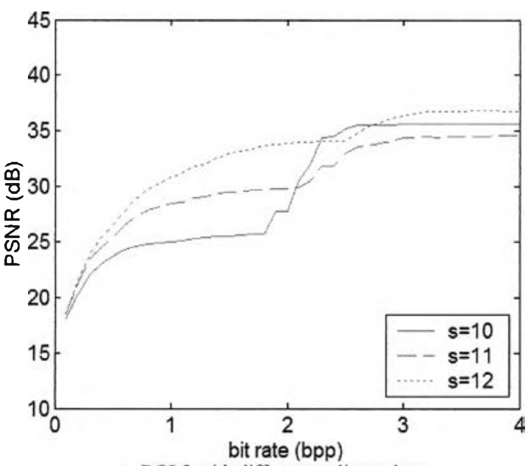
In this paper, we have combined two methods of ROI coding in JPEG2000, the PSB shift is used as the base method and the Maxshift is used to improve the ROI quality lacking in PSB. Combination of these two methods does not require the encoder to send ROI shape information. Simulation results show that the proposed method achieves the better quality in ROI and also has an ability to adjust degree of interest finer than only PSB shift.



a. ROI-1 with different scaling values.

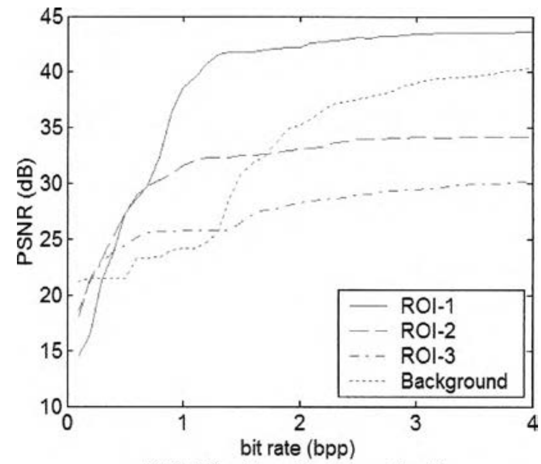


b. ROI-2 with different scaling values.

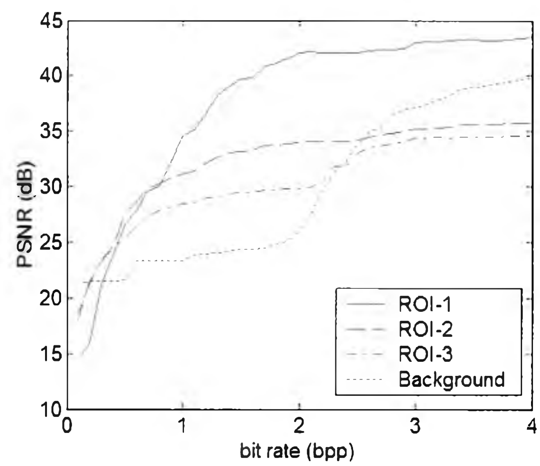


c. ROI-3 with different scaling values.

Fig. 6. The proposed method with degree of interest.



a. PSB shift with scaling value, $S = 11$.



b. The proposed method with scaling value, $S = 11$.

Fig. 7 PSNR of ROIs and background.

a. ROI-1

b. ROI-2

c. ROI-3

Fig. 8. Subjective comparisons of the second experiment. From left to right is PSB shift, Original image and the proposed method.

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ประวัติผู้เขียนวิทยานิพนธ์

นายพิริยะ กิตติวรรธนกุล เข้าศึกษาในหลักสูตรวิศวกรรมศาสตร์บัณฑิต คณะวิศวกรรมศาสตร์ มหาวิทยาลัยเกษตรศาสตร์ในปีการศึกษา 2541 จบการศึกษาในปีการศึกษา 2544 ได้รับ วศ.บ. ไฟฟ้า และเข้าศึกษาต่อในหลักสูตรวิศวกรรมศาสตร์มหาบัณฑิต ที่ห้องปฏิบัติการวิจัยวิธีสัญญาณดิจิทัล ภาควิชาวิศวกรรมไฟฟ้า จุฬาลงกรณ์มหาวิทยาลัยในปีการศึกษา 2545