Lossless Transform with Thumbnail Previewing and Transcoding Functionality

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***Abstract*— This report proposes a new functionality of lossless coding of image signals. The proposed method provides 'thumbnail previewing' and 'Transcoding' of the original image without expanding the data components of compressed bit-stream. It also abstains from the reduction of resolution in image pixels. It is composed of a new lossless color transform and an existing lossless wavelet transform. We add a free parameter to the existing color transform and utilize it to control a scaling parameter of the luminance component. Consequently, it becomes possible to preview the 'thumb-nail' image from a part of the bit-stream. Due to the free parameter of scaling part, quality and data volume of the 'thumb-nail' image can be controlled according to the users' request. Moreover, it still keeps the transcoding function for standard lossy decoder usage. It uses the scaling part in the decoder part for 'transcoding' between lossless-lossy coding.**

Keywords—lossless; lossy; transcoding; thumbnail

I. INTRODUCTION

Due to the wide usage of lossless compression such as medical image, quality of the image compression is the key technology. Therefore, functionality of lossless transform would be an advantage for users. This report focuses on transcoding between lossless encoder and lossy decoder based on JPEG2000.

The standard JPEG2000 [1] provides both of the lossy coding and the lossless coding. Since of the 'lossy' coding and 'lossless' coding are based on different signal processing modules, lossless-lossy transcoding cannot be applied normally.

So far, "Lossless-Lossy" discrete wavelet transform (DWT) have also reported. In [2], [3], a interger version of 2D 9/7 DWT lifting structure compatible with irreversible DWT also were proposed. These reports increase compatibility of transcoding between lossless and lossy based on a reversible 9/7 DWT for monochrome images. Hence, an integer color transform (IntCT) compatible with an irreversible color transform (IrrCT) is required. This report applies it in color image.

An integer color transform (IntCT) compatible with the IrrCT in JPEG 2000 has been proposed in [4]. It is composed of three lifting steps. Adding one more lifting step, another type of the IntCT have been proposed in [5], [6].

In [7], IntCT [8] has been improved to be a transcoding system between lossless encoder and lossy decoder. It reported compatibility of transcoding between IntCT and IrrCT by embedding scaling of the existing IntCT into inverse quantization procedure of lossy decoding.

In this report, we add a free parameter to the four lifting step IntCT, and utilize it to control image quality of a 'thumbnail' image. In the proposed method, a luminance image as the 'thumbnail' can be decoded from a part of the bit-stream. Due to this functionality, it keeps transcoding function and becomes possible to preview the original image without expanding all the compressed data file. Quality and data volume of the 'thumb-nail' image can be also controlled with the free parameter according to the users' request.

II. EXISTING METHOD

A. *Existing Method*

Fig.1 illustrates the existing method. Transcoding between a "lossless" encoder and a "lossy" decoder for color images was proposed [7]. It used a 9/7 DWT in integer version which can be utilized for lossless coding. Moreover, it proposed integer color transform (IntCT) compatible with the irreversible color transform (IrrCT) in JPEG 2000. It is composed of three lifting steps and scaling part to make compatibility between lossless-lossy.

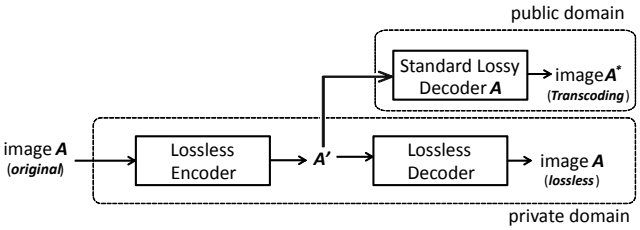

Fig. 1 Existing method [7]

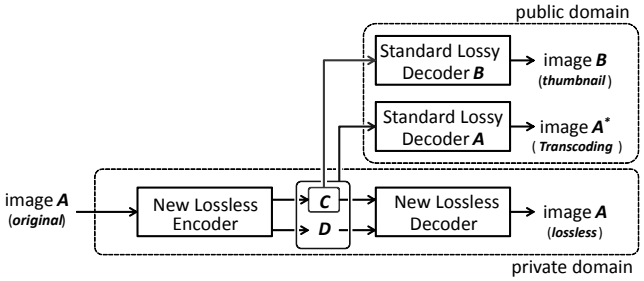

Fig. 2 Proposed method

B. *Functionality approach*

To add more 'thumbnail previewing' functionality, Fig.2 illustrates the proposed method. The original image ***A*** is compressed with the new 'lossless' encoder. It is decoded

without any loss from both of the bit streams (compressed data) '***C***' and '***D***'. It has transcoding functionality that a standard 'lossy' decoder can be applied to those bit streams to decode an approximation A* of the original image A. Unlike the previous IntCT [7], we add a free parameter to the four lifting step IntCT, and utilize it to control image quality of a 'thumbnail' image. In the proposed method, a luminance image as the 'thumbnail' can be decoded from a part of the bit-stream. So that image ***B*** can be also decoded from the bit stream '***C***', under the constraint that image ***A*** and ***B*** have the same number of pixels (resolution).

III. PROPOSED METHOD

A. *Overview of the Proposed Method*

Fig.3 illustrates the proposed method in detail. The lossless transform is composed of the 'Lossless Color Transform' and the 'Lossless DWT'. The latter is the integer version [2] of the 9/7 DWT (labeled as 'Lossy DWT' in the figure) defined by JPEG 2000 for lossy coding [1]. Originality of this report, we modify a former 'Lossless Color Transform' to be a new IntCT for extend more functional without any expand the data component.

In lossless coding mode, the lifting $\mathbf{L}_p$, $p \in \{1,2,3,4\}$ and the permutation **P** are applied to color components $\{R, G, B\}$ of the original image ***A***. Each of the color components $\{y, c_R, c_B\}$ are fed into the lossless DWT and then entropy coded. Total data volume of ***C*** , ***D*** and ***D2*** stay the same as standard lossless encoder.

In the 'thumbnail' mode, this is the originality of this report, only the data ***C*** is decoded with a conventional 'Lossy DWT'. Its pixel values are multiplied with the coefficient '*i*' in the scaling **S**, to produce the 'thumbnail' image ***B***. This coefficient 'i' is the free parameter in our proposal to control quality and data volume of the thumbnail image B as indicated in the next section.

In the 'Transcoding' Mode, a conventional 'lossy' decoder can be applied to ***C, D1*** and ***D2*** to decode the approximation ***A**** of the original image ***A***. In this lossless / lossy transcoding coding mode, the scaling **S** is applied in the decoder side as previous report [7].

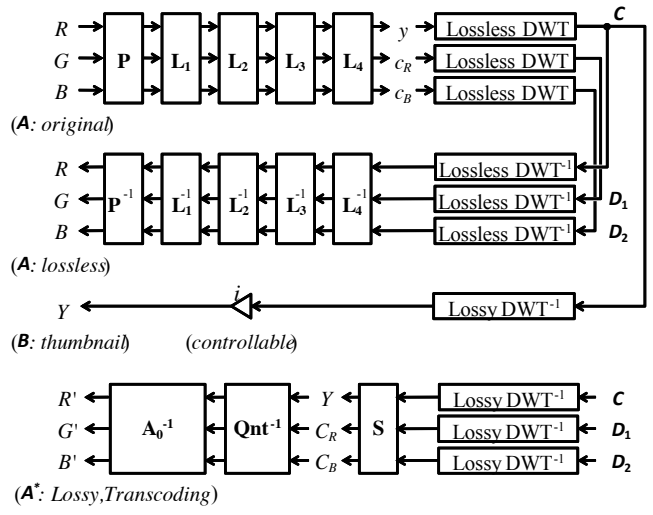

Fig.3 Proposed method each mode.

B. *Concept for Thumbnail Functionality*

Fig.4 and Fig.5 illustrate IntCT of existing and proposed method. We proposed new IntCT which is composed of four lifting steps {**L1, L2, L3, L4**} from previous IntCT [2]. The permutation **P** is carefully selected from its variations so that the system becomes robust to the rounding errors [9,10]. It also contains the scaling **S**. However, This part is not used in the lossless coding mode.

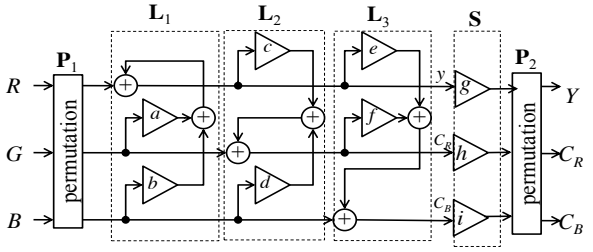

Fig. 4 Integer Color Transform in the existing method [2]

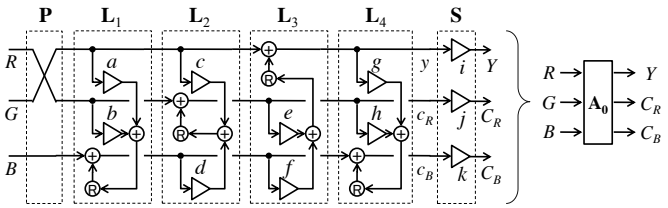

Fig. 5 Integer Color Transform in the proposed method

The coefficients $\{a,b,c,d,...,k\}$ are determined. Therefore, this color transform matrix is delight from a given color transform matrix $\mathbf{A}_0$ (1) same as in the conventional decoder ***A*** in Fig.1. Note that some of the coefficients can be zero as stated in [11]. However, we utilize this redundancy as the freedom of controlling quality of the thumbnail image ***B*** in Fig.3.

$$\mathbf{A}_0 = \begin{bmatrix} .2999 & .5870 & .1140 \\ .5 & -.4187 & -.0813 \\ -.1687 & -.3313 & .5 \end{bmatrix} \tag{1}$$

C. *Determination of the Coefficients*

For a given lossy color transform $\mathbf{A}_0$ in the 'conventional decoder ***A***' in Fig.5, the coefficients $\{a,b,c,d,\cdots k\}$ are determined as below.

$$k = |\mathbf{A}|/(ij), \quad d = U/j, \quad b = (T-j)/U \tag{2}$$

$$\begin{bmatrix} g \\ h \end{bmatrix} = \begin{bmatrix} R/i & U/j \\ Q/i & T/j \end{bmatrix}^{-1} \cdot \begin{bmatrix} X/k-1 \\ W/k-b \end{bmatrix} \tag{3}$$

$$\begin{bmatrix} a \\ c \end{bmatrix} = \begin{bmatrix} -P/i & -S/j \\ UP/(ij) & US/j^2 \end{bmatrix} \begin{bmatrix} g \\ h \end{bmatrix} + \begin{bmatrix} V/k \\ S/j - UV/(jk) \end{bmatrix} \tag{4}$$

$$\begin{bmatrix} f \\ e \end{bmatrix} = \left(\begin{bmatrix} Q/i & T/j \\ R/i & U/j \end{bmatrix} \begin{bmatrix} g \\ h \end{bmatrix} - \begin{bmatrix} W/k & -T/j \\ X/k & -U/j \end{bmatrix}^{-1} \cdot \begin{bmatrix} -Q/i \\ -R/i \end{bmatrix} \right) \tag{5}$$

for

$$\mathbf{A}=\begin{bmatrix} P & Q & R \\ S & T & U \\ V & W & X \end{bmatrix}=\mathbf{A}_0\cdot\mathbf{P}^{-1}. \quad (6)$$

In this form, two of the coefficients are redundant. For example, setting [g h]=[0 0] results in the three lifting step IntCT in [4]. In this report, we set h=0 to obtain one free parameter i. Substituting (2) into (3), we have

$$\begin{bmatrix} g \\ h \end{bmatrix}=\frac{1}{M_{31}}\left(\frac{ij}{|\mathbf{A}|}\begin{bmatrix} +iM_{11} \\ -jM_{21} \end{bmatrix}+\frac{j}{U}\begin{bmatrix} 0 \\ M_{31}+Rj \end{bmatrix}\right). \quad (7)$$

Setting h=0 in (7), we have

$$j=\frac{M_{31}|\mathbf{A}|}{iM_{21}U-R|\mathbf{A}|} \quad (8)$$

for

$$M_{11}=\begin{vmatrix} T & U \\ W & X \end{vmatrix},\quad M_{21}=\begin{vmatrix} Q & R \\ W & X \end{vmatrix},\quad M_{31}=\begin{vmatrix} Q & R \\ T & U \end{vmatrix}. \quad (9)$$

Consequently, all the coefficients are determined according the free parameter i.

IV. Experimental Results

From Fig. 3, we investigated the experimental in 3 points of Functional. These points compose of 'Lossless', 'Thumbnail' and 'Transcoding' mode. This report used 256x256 pixels Lenna images for experiment samples. We evaluate lossless performance by using average bitrate for comparison of compression efficiency. To evaluate quality of reconstructed image signal, PSNR (Peak Signal to Noise Ratio) is used for lossless performance modes (thumbnail and transcoding mode).

A. *Lossless Performance*

In Fig.6, it was confirmed that there is no significant difference if we compare lossless performance between proposed lossless encoder and standard JPEG2000 lossless encoder in criteria bitrate.

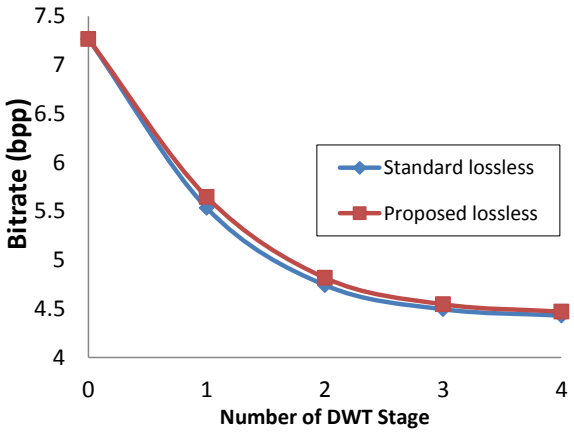

Fig.6 Lossless performance of proposed method

B. *Thumbnail Previewing Performance*

As one free parameter for $i\in\{1,2,3,\ldots,8\}$, image quality and data volume of the thumbnail ***B*** can be controlled with varying the free parameter i as shown in Fig.7, Fig.8 and Fig.9. Data volume of thumbnail will be reduced when parameter i increasing. On the other hand, show that quality of thumbnail previewing will be reduced when parameter i decreasing.

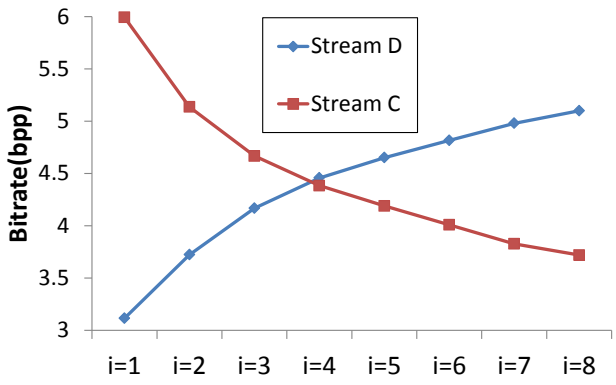

Fig. 7 Data volume of thumbnail in condition of i varying

Stream C is used for thumbnail previewing. Fig. 7 indicates that data volume can be controlled with the free parameter i. Otherwise data volume of stream D (average of the rest of color component) will be increased by increasing of parameter i. Since, the total data volume is constant when stream C was controlled.

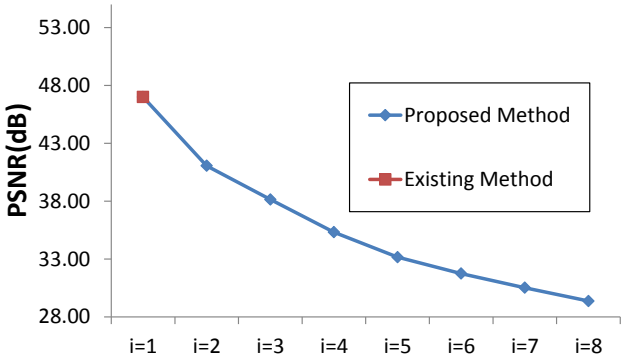

Fig. 8 PSNR of thumbnail in condition of i varying

Our proposed by free parameter controlling, quality of thumbnail previewing image will be reduced when parameter i decreasing. However, i parameter will be controlled on user's request. The lower quality thumbnail still can be access in small thumbnail size in lower data volume.

Fig.9 shows the result of quality image thumbnail previewing in each stage of Discrete Wavelet Transform (DWT).We vary i for $i\in\{1,2,3,\ldots,8\}$ by fourth stage DWT normal application. For lossy DWT^{-1}, the quality of thumbnail image supposed to be decreased by every stage applicable.

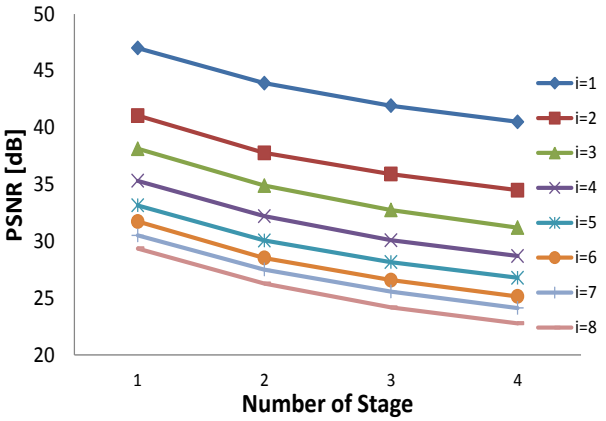

Fig. 9 Image quality of thumbnail in condition of *i* varying

PSNR=33.157849

Fig.10 example decoded thumbnail image for *i*=5

Fig. 10 shows that for *i*=5, image signal bitrate was reduced. The thumbnail previewing can be used in image previewing.

C. Transcoding Performance

In criteria of transcoding performance, Fig.10 and Fig.11 experimentally confirmed that it can keep transcoding performance.

PSNR=45.029217

Fig.10 example decoded transcoding image

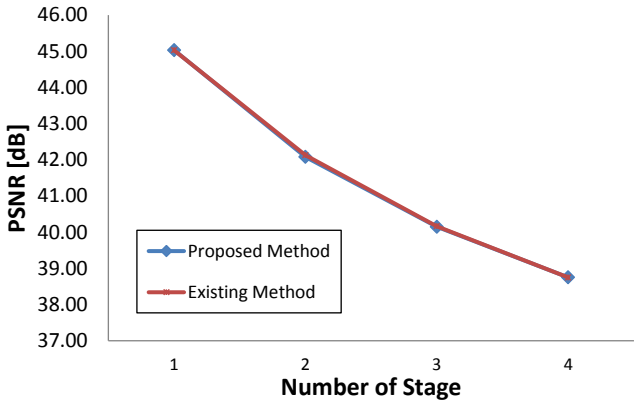

Fig.11 Transcoding performance between proposed IntCT and previous IntCT[7]

In Fig.11, we compare the proposed method performance result with previous IntCT[7] with the same condition of permutation matrix.

V. CONCLUSION

A free parameter of the four lifting integer color transform was utilized for previewing a thumbnail image. Its quality and data volume were controlled according to a user's request, under the constraint that pixel density of the thumbnail image is the same as the original image. As the results, this system still keeps the transcoding function and also applies thumbnail previewing functionality in advantage as summary in Table I.

Since the thumbnail image is limited to monochrome, it should be extended to color in the future.

TABLE I. COMPARISON OF FUNTIONALITY EFFORT

	Lossless	Thumbnail with Quality Control	Transcoding
Standard JP2K	✓	×	×
Existing	✓	×	✓
Proposed	✓	✓	✓

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