An Optimization of Progressive Transmission Based on a Variable Frequency Band Division Method

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Abstract

Generally, the image transmissions need more time to be made in comparison to text data, although Progressive JPEG makes it possible for users to see an approximation to the whole image in the early stage with gradual improvement of quality. However, the progressive method does not provide us the way in which we should divide the frequency bands.

In addition, it causes such problems that the progressive displaying is uncomfortable with users because of its inconstant refreshment depending upon the data size or transmission environments. Therefore, we propose the method of frequency band division which enables users to feel natural progressive displaying by means of constant refreshment based on the coding rate to maintain an adequate balance between data amount and PSNR (Peaked Signal Noise Ratio).

Introduction

Huge data of multimedia have been transfer under the Internet environment over the world [1] [2] [3]. The users demand for the dealing with images data effectively. Progressive JPEG is one of the most useful image file format. It makes possible for users to recognize a rough image without receiving all data, to get relief from the stress of a waiting time and for network to reduce opportunities of heavy traffic.

However? When it comes to with gradual improvement of quality in progressive JPEG, the way of improvement of quality is not regulated and the each producers of an image defines it. The improvements of images are different depending on the transmission environment of each user without producer's intent.

Therefore, we proposed the method of frequency band division which enables users to feel natural progressive displaying by means of constant refreshment based on the coding rate. We developed the coding algorithm in JPEG and JPEG2000 [4] [5] based on DCT or DWT, and we evaluated this algorithm by means of the test of subjects.

The method for JPEG based on DCT

Problem of progressive JPEG

DCT coefficients are divided into preset bands and the images are displayed progressively in progressive JPEG. The first transmission data is defined as a DC component and the AC components are divided into from low frequency to high frequency and transmitted gradually. However, there is no regulation concerning the way of dividing band frequency in the conventional transmitting methods. This method presets a static division of the frequency bands into DCT coefficient and it causes the problem that the image quality does not improve smoothly in a uniform time interval and not naturally for human feeling according to image compression rate and communication status.

Proposal variable frequency band division method

We propose the new method which is the dynamic division way according to the quantity of image data for JPEG. This method divides the data of each frequency band into the same quantity based on the coding image data. [6] As a result, we have established a progressive coding algorithm, which makes it possible for the transmitting data in the network to be constant, and the image quality improves smoothly in a uniform time interval.

We show an example of displaying under the conventional method and our proposal method.

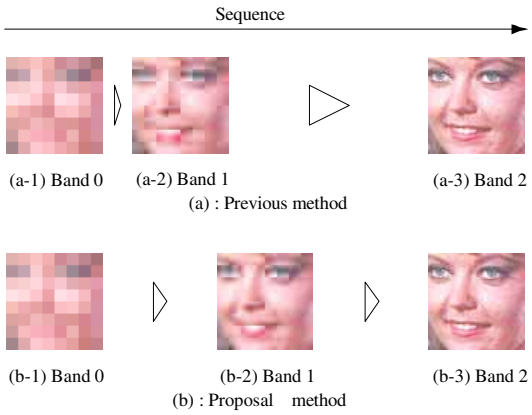


figure 1 The sequence of displayed image

The framework of the frequency band division is shown in figure2. DCT coefficients from DC component to AC63 are ordered in zigzag scan. The each DCT blocks of the static image is ordered in raster scan in the each column of DCT blocks. Assumption: DCT block size is 8x8 and 64 DCT coefficients are provided. The number of progressive level is N.

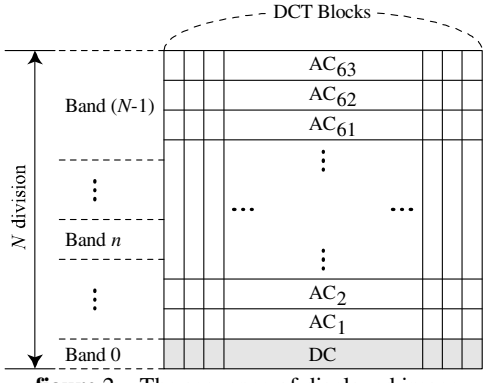


figure 2 The sequence of displayed image

The algorithm of proposal method consists of the following process.

Step1 Calculating frequency components

Apply DCT to the image data in order to obtain DCT coefficients

Step2 Encode the DC components

Encode the DC components under Band 0 as regulated in progressive JPEG (The gray area in figure 2 is encoded.)

Step3 Calculate the data size in each frequency band

The data amount of equal division for total AC components is ΔB.

$$\Delta B = D/(N-1) \quad (1)$$

D is the summation of the data size of each AC components applied by Huffman coding (from AC1 to AC63).

ΔB is defined as the data size of each frequency band

Step4 Processing of equal division for frequency band

1. Initial condition

Band n: $\{AC_s, \ldots, AC_{s+t}\}$

$n=1\ (1 \le n \le N-1)$, $s=1\ (1 \le s \le 63)$, $t=0\ (0 \le t \le 63-s)$

2. Huffman coding for Band n

Calculate B_n by Huffman coding

B_n: The band size of Band n

3. Calculating the band size difference

Calculate the absolute value of the difference

$$\Delta d_n = | \Delta B - B_n | \quad (2)$$

4. Judgment for equivalent division

If Δd_n is minimum, exit the calculating of Band n by Huffman coding.

If not, return to 2 as t=t+1

5. Judgment for the end of process

n←n+1, s←s+t+1,t←0

If n<N-1, return to 2.

If n=N-1, exit coding process.

The last frequency band components are defined as follows.

Band n: $\{AC_s, \ldots, AC_{63}\}$

The method for JPEG2000 based on DWT

We have also applied the idea of "variable frequency band division " to JPEG2000 on DWT.

We propose the new method which is the dynamic division way according to the quantity of transmitted data for JPEG2000.

This method provides the order to be sent of image data based on the ratio of completion of transmission to before transmission. That is the transmission priority is provided to the least amount of the completion of transmission. As a result, we have established a progressive coding algorithm, which makes it possible for the transmitting data in the network to be constant, and the image quality improves smoothly in a uniform time interval.

The framework of the frequency band division is shown in figure. We adopt not basic decomposition but the Standard decompoposition2 of DWT in order to divide high frequency components and it enables us to control progressive displaying in detail. And we take particular note of each small area in static image in order to provide the more precise controls and apply to the concept of ROI. [7] Figure 3 shows the divided small areas and ROI.

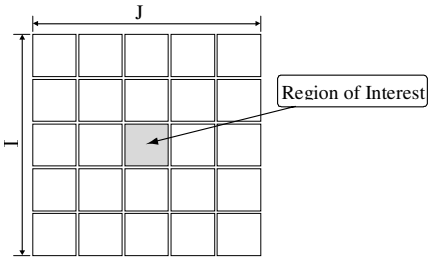


figure 3 Division into I×J of static image

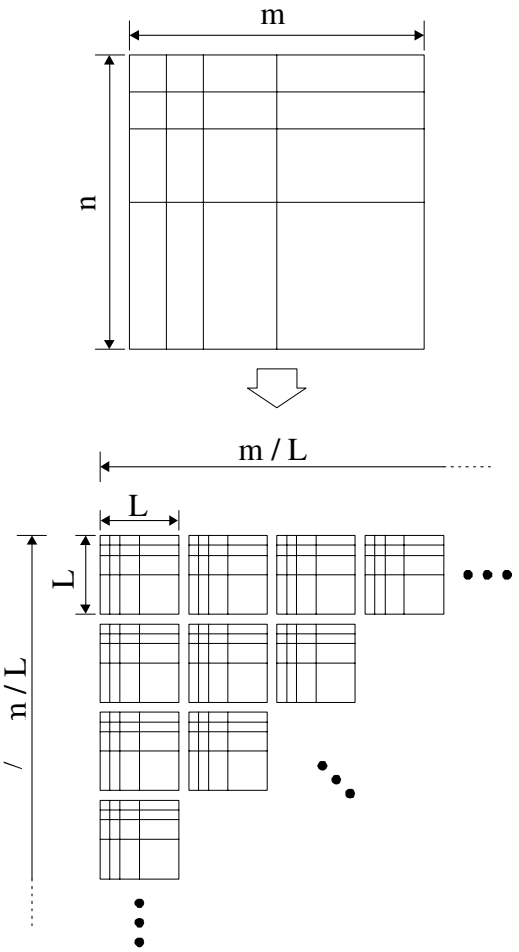


figure 4 The block division of DWT coefficient

Moreover, we add the concept of the block division of DWT coefficients out of the ordinary. This block division is shown in figure 4.

The size of m×n DWT coefficients are divided into the blocks which size is L × L. (L =8 in this paper) So, the number of DWT blocks is m/L × n/L. The DWT coefficients of each block are divided into the number of K. And they are applied to progressive processing from 0 level to K-1 level. The number of level for progressive is K.

The algorithm of proposal method for DWT consists of the following process.

Step1 Set the small areas

Set the areas of the number of I×J into the static image

Calculate D (i, j), which is the total amount of image data in small areas (i, j).

Calculate every generation probabilities of the DWT coefficient in each small area by means of dividing the number of every DWT coefficient value by total number of DWT coefficient

Calculate the data amount of each DWT coefficient based on previous generation probabilities in small area

This is define as d (i,j,h) ." h" is the suffix expressing the order of DWT coefficient transmission.

Step2 Set the progressive coding number 0

Coding number in progressive process is defined as k (0 < k < K-1).

Set the DC components as k=0.

Set k← k+1

Step3 Set the ratio of transmission

dr (i,j,h) is also defined as the data amount of DWT coefficient which has already been transmitted in the small area (i,j).

DR(i,j,h) is defined as the ratio of transmission in small area at each DWT coefficient.

$$DR(i,j,h) = dr(i,j,h) / D(i,j) \quad (3)$$

Step4 Select the area which has minimum of DR (i,j,h)

The data amount of transmission should be constant in order to provide the natural improvement in progressive process. The priority of the transmission is provided to the minimum DR area. Calculate minimum DR is selected and h is set as 0. That is DR(i,j,0)

Step5 Update of the ratio of transmission

Set h← h+1

And update DR(i,j,h)

Step6 Set the progressive coding number

When the total amount of transmitting date converges to constant value, k ←k+1

In other case, return to step5

Step7 Judgment for the end of process

When k=K, exit this process

Evaluations

Experiment of the method based on DCT

We compared the coding rate and PSNR of the image with conventional method at the same frequency band for different quantization quality.

The standard image "Girl" was used under the following conditions.

q= 20 N=4(Band 0-Band3) and # q= 80 N=4(Band 0-Band3)

The Quantization Table Q (u, v) in this experiment is followed with appendix K of JPEG standard is used for in this experiment and Q(u,v) is scaled as α× Q(u, v).

$$\alpha = 50/q \qquad 1 \le q \le 50 \quad (4)$$

$$\alpha = 2 - q/50 \qquad 50 < q \le 100 \quad (5)$$

$$1 \le \alpha \times Q(u,v) \le 255 \quad (6)$$

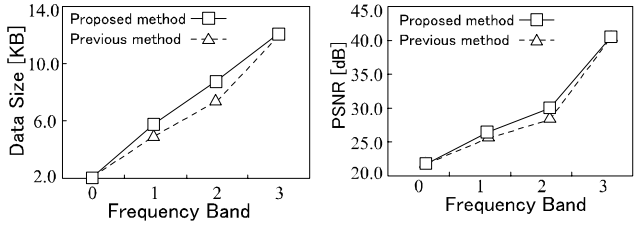
The results of proposal method and conventional method for frequency band are shown in Table 1.

The values of the table are the orders of zigzag scan for AC components. 0 means DC components.

Frequency Band	Proposal Method		Conventional Method	
	q = 20	q = 80	q = 20	q = 80
Band 0	0	0	0	0
Band 1	1-2	1-3	1-2	1-2
Band 2	3-5	4-8	3-5	3-5
Band 3	6-63	9-63	6-63	6-63

Table 1 Comparison of Frequency Band

The comparison for coding rate and PSNR respectively is shown in figure5.



(a) Coding rate (b) PSNR

figure 5 Comparison of coding rate and PSNR

The rapid data transmission appears at Band3 at the conventional method in (a). On the other hand, the data size grows constantly and it shows that data transmission is constant. And also, it presented that PSNR does not rise rapidly.

Experiment of the method based on DWT

We compared the methods of data transmission in JPEG by means of the subjects

Constant transmission (Proposal method)

The same amount of the data is transmitted in each progressive level.

Detail transmission in the early level

The low frequency components, which are transmitted in early level, are given fine divisions and high frequency components are transmitted at one time.

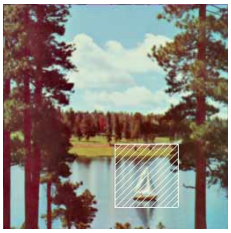
Rough transmission in the early level

The low frequency components are brought together and high frequency components, which is transmitted in late level, are given fine divisions

The 3 images are used for the evaluation in figure 6.

(a) Couple

(b) Lenna



(c) Sailboat

figure 6 Figures for experiment

We asked to the subjects "What way is the most favorable or comfortable for each image?"

The result of questioner is shown in figure 7.
It recognized that most users favored the way of constant transmission. We considered that the user are able to expect the time to completion of receiving data and improvement ratio of precision of image under the low speed communication in advance and the images are retrieved in effective.

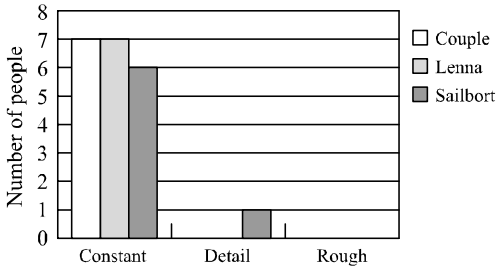


figure 7 Comparison of transmissions

Experiment of the method based on DWT 2
We evaluated the coding rate and PSNR of the 3 images in fig 7. ROI is set to each image in advance. (K=6 and I×J=5×5)
The results for each image are shown in figure .8.1 and 8.2.

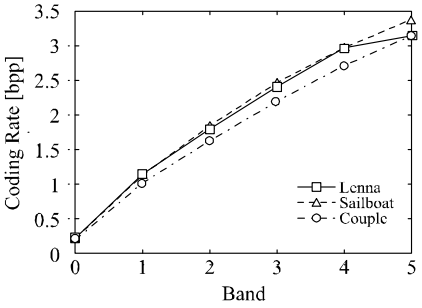


figure 8.1 Coding rate for each image

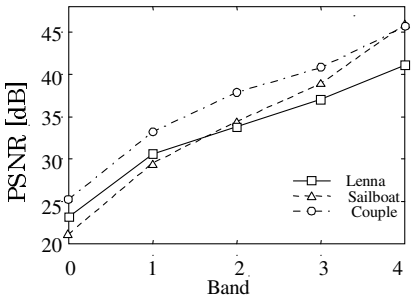


figure 8.2 PSNR for each image

It shows that the rate of increase in coding rate (a) and in PSNR (b) are almost constant in each band. It indicates that the user can recognize the enhancement of image quality by regular time interval.

Conclusion

We proposed the method of frequency band division which enables users to feel natural progressive displaying by means of constant refreshment based on the coding rate. We applied new coding algorithms to DCT in JPEG and DWT in JPEG2000, and we evaluated the effectiveness of these algorithms and realized that they make it possible to display the image progressively in a uniform time interval.

We consider that it is possible to establish an optimized image transmission system of image data under the various networks such as from narrowband to broadband. It will be useful for users to retrieve images and relief their own stresses in connecting into bad network.

References

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Author Biography

Kanazawa Tomonori received his BS in computer science from Ehime University JAPAN (1999) and her MS in computer science from Ehime University JAPAN (2001). Now he is researching in eCompute Corporation.