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DCT 부호화 영상의 최적 비트 정렬에 의한 점진적 전송

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Progressive transmission using optimun bit-ordering of DCT coded image

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요 약

전체 부호화 비트중 일부 비트이 수신만으로도 나은 양호한 영상을 재생할 수 있는 DCT 부화화 영상의 최적 비트 정열에 의한 점진적 전송을 제안하였다. 이는 한 비크 더 전송함으서 재생 영상의 왜곡을 가장 많이 줄이는 비트부터 단계적으로 전송하는 것이다. 이를 위해서 Embedded 양자화기의 재생 레벨과 한 비트 더 전송함으로서 얻어지는 새로운 재생 레벨과 차의 제곱을 의미하는 PTF를 정의하였으며 부호화 비트에 대한 PTF를 순차 정렬함으로서 비트 전송 순서를 얻었다. 결과로 제안한 방법은 기존의 zig-zag 주사에 의한 전송보다 동일 비트율에서 작은 왜곡과 보다 나은 화질을 갖는 영상을 재생할 수 있었다.

ABSTRACT

Progressive transmission using optimum bit-ordering of discrete cosine transform(DCT) coded image is proposed to reconstruct a better image in a few bits among all the coded bits at the receiver. It is to transmit the bit gradually to reduce the distrotion of the reconstructed image most by transmitting one more bit. To do this, the power transfer factor(PTF) which is the squared value of difference between the reconstruction level of embedded quantizer and another reconstruction level made by transmitting one more bit is defined. And then, the rransmission order of bits is obtained by sorting the PTFs of the coded bits. As a result, the proposed method can reconstruct image having less distortion and better quality at the same bit rate than the conventional zig-zag scan.

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Ⅰ. INTRODUCTION

In image communication systems such as videotex, medical diagnostic imaging, electronic shopping in mail order and access to large database, the time taken for an image to be transmitted entirely and displayed on the screen can be considerable because of the large amount of image data[1,2,4-7]. Therefore, the way building up the image progressively from the moment the first pixel received until the last pixel displayed to the screen is important. Progressive reconstruction of an image can give a rough approximation of the image first, and then gradually build up the image in detail according to the amount of transmitted information [7,9,10]. This technique is especially useful for still image retrieval because the transmission of an image can be aborted as soon as the received image is recgnized as not being the desired one[7,9].

Image coding having progressive transmitability can be divided into transform domain methods[1,2,3,12] and spatial domain methods [4,5,6,8,-10]. In the transform domain methods, a rough approzimation of the image can be obtained easily by transmitting only low order transform coefficients since low order transform coefficients have almost all the power of image signal. On the spatial domain methods, first an image is strutured with pyramid plane according to detail of the image, and a pyramid plane with low detail is transmitted and then pyramids woth more detail progressively[6,8].

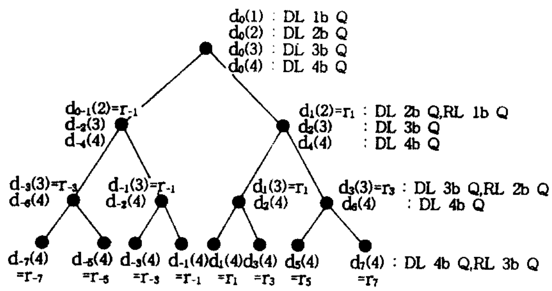
Progressive transmission using zig-zag scan of coefficients in the tranform domain [2] has not considered the information that one bit, the least unit of information, is able to transmit. Bit-sliced progressive transmission [12], a method of bit unit transmission using embedded quantizer [11], has less distortion in the reconstructed image for some bits transmission among all the coded bits than zig-zag scan. But it has much greater distortion for all the coded bits transmission than zig-zag scan because embedded quantizer's reconstruction level is not equal to Lloyd-Max quantizer's [13,14] and only one embedded quantizer is used to all the coefficients [12]. The embedded quantizer [11] is designed using 4 bit Lolyd-Max quantizer reference quantizer.

To reconstruct a better image in a few bits among all the coded bits at ehr receiver, progressive transmission using optimum bit-ordering of DCT coded image is proposed in this paper. It is to reansmit the bit gradually to reduce the distortion of the reconstructed image most by transmitting one more bit. To do this, the power thansfer factor(PTF) which is the squared value of difference between the reconstruction level of embedded quantizer and another reconstruction level by transmitting one more bit is defined. And then, the transmission order of bits is obtained by sorting the PTFs of the coded bits.

Progressive transmission using optimal bit-ordering is applied to the DCT coded image with zonal sampling[15] and is compared with conventional zig-zag scan of coefficients[2].

Ⅱ. Embedded Quantizer

Embedded quantizer was introduced by Tzou [11], which could be used to reconstruct a better image in a few bits in the bit-sliced transmission of the DCT coded image [12]. He pointed out Lloy-Max quantizer is not suitable for emvedded quantizer [11]. Therefore he designed an embedded quantizer using binary tree as a threshold alig-



DL kb Q : decision levels of k bits Quantizer
RL kb Q : reconstruction levels of k bits Quantizer

Fig. 1. Binary tree for the decision and reconstruction level of embedded quantizer

ned quantization as shown in Fig. 1, which considers reconstruction levels as decision levels of quantizer having one more bit.

A. Optimum reconstruction level design with transmitted bits (Method 1)

We now desige the embedded quantizer's reconstruction levels proposed by Tzou[11]. For a given k bit quantizer for input X with unit variance, consider decision level $d_{-2^{k-1}} = -\infty$, $d_0 = 0$ and $d_{-2^{k-1}} = \infty$ and t as the number of transmitted bits from MSB and j as reconstruction level index of embedded quantizer according to the number of transmitted bits. The reconstruction level γ_{ktj} to have minimum mean squared distortion is given as Eq. (1)

$$\gamma_{ktj} = \frac{\int_{d_{(j-1)2^{k-t}}}^{d_{j2^{k-t}}} xP(x)\,dx}{\int_{d_{(j-1)2^{k-t}}}^{d_{j2^{k-t}}} P(x)\,dx} \tag{1}$$

$$\gamma_{kt-j} = -\gamma_{ktj} \tag{2}$$

where t=1, . . . , k-1 and j=1, . . . , 2^{k-t+1} and p (x) is probability density function of input X.

B. Resonstruction level design using Lloyd-Max quantizers (Method 2)

Modification of embedded quantizer's reconstruction levels is introduced here. Reconstruction levels of Lloyd-Max quantizer whose bits number is equal to the number of transmitted bits can be used as those of embedded quantizer for some bits transmission from MSB. Although this method has a little more distortion than the Method 1, it is very simple.

III. Progressive transmission using optimum bit-ordering

In general, variances used in the normalization of coefficients in the quantization procedure are estmated using bit allocation map and constant to estimate variance at the receiver [12,15,16]. Therefore, coefficients using the same quantizer for some bits transmission, the bit to be transmitted next must be one bit of the coefficient to reduce distortion of the reconstructed image nost. This is resulted from that the bit having higher reconstruction level can transfer more power than the bit having lower reconstruction level in the progressive transmission of DCT coded image. For this reason, we define PTF here. PTF is the squared difference between the reconstruction level of embedded quantizer and another reconstruction level of the quantizer which is made by transmitting one more bit. Each coefficient has its own embedded quantizer and than a unique PTF. PTF is given as Eq. (3).

$$P_{kt-1j} = \begin{cases} \gamma_{kt1}^2 P(\gamma_{kt1}^2), & t=1 \\ \{[\gamma_{kta} - \gamma_{kt-1j}]\}^2 P_1 + [\gamma_{ktb} - \gamma_{kt-1j}]^2 P_h\}, & t \neq 1 \end{cases} \tag{3}$$

$$P_l = \frac{P(\gamma_{kta})}{P(\gamma_{kta}) + P(\gamma_{ktb})} \tag{4}$$

$$P_h = \frac{P(\gamma_{ktb})}{P(\gamma_{kta}) + P(\gamma_{ktb})} \tag{5}$$

where t = 1, 2, . . . , k

j = 1, 2, . . . , 2^{t-2}

a = 2j-1, b = 2j

P( ) : probability of reconstruction level of embedded quantizer

P_{kt-1j} is the power ot be transferred by the t th bit "0" or "1" transmission to the level j reconstructced with (t-1) bits.

To decide the transmission order of all the coded bits, bit-ordering is done by sorting PTFs in descending order which consider variance of coefficient. And then, the coded bits are transmitted according to the bit-order.

For example, consider the reconstruction levels of 3 bits embedded quantizer shown in Fig. 2.

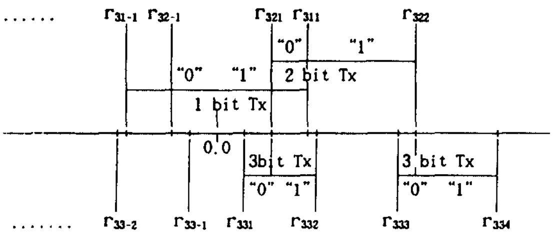


Fig. 2. reconstruction levels according to bit transmission

When the reconstruction level for 2 bits transmission is γ_{321}, the reconstruction level according to the next transmission bit "o" or "1" γ_{321} or γ_{332}. And so, PTF P_{321} is

$$P_{321} = 2\{[\gamma_{331}-\gamma_{321}]^2 P(\gamma_{331})/P(\gamma_{331})+P(\gamma_{332})) + [\gamma_{332}-\gamma_{321}]^2 P(\gamma_{332})/P(\gamma_{331})+P(\gamma_{332}))\}$$

In a similar method, when the reconstruction level for 2 bits transmission is γ_{322}, the reconstruction level according to the next transmission bit "0" or "1" is γ_{333} or γ_{334}. And so, PTF P_{322} is

$$P_{322} = 2\{[\gamma_{333}-\gamma_{322}]^2 P(\gamma_{333})/P(\gamma_{333})+P(\gamma_{334})) + [\gamma_{334}-\gamma_{322}]^2 P(\gamma_{334})/P(\gamma_{333})+P(\gamma_{334}))\}$$

For two coefficients having same estimated variance σ^2 in the DCT coded image, if the reconstruction levels of two coefficients using 3 bits embedded quantizer are $\sigma\gamma_{321}$ and $\sigma\gamma_{322}$ for 2 bits transmission, the bit of coefficient whose reconstruction level is $\sigma\gamma_{322}$ must be transmitted first for next bit transmissio because $\sigma^2 P_{322}$ is larger than $\sigma^2 P_{321}$. In the encoder and decoder, it is necessary to store levels reconstructed with transmitted bits for every subblock to identify the coefficient of bit to be transmitted for each subblock.

Ⅳ. SIMULATION RESULTS

Computer simulation of the progressive transmission using optimum bit-ordering with PTE is performed and compared with zig-zag scan transmission. The proposed method was applied to 'CRONKITE' image of 256X256 size with 256 gray level. A subblock size of 16x16 was used for DCT.

To evaluate the coder performance perceptually and numerically, not only the perceptual image quality was used but the noise ratio between the original image O(m,n) and the reconstructed image Y(m,n) has been calculated, where NR is defined as

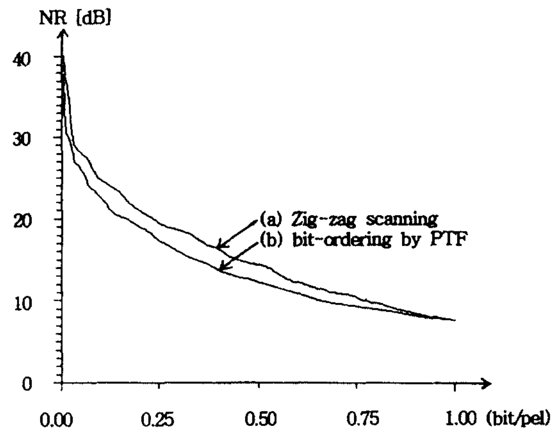


Fig. 3. NR according to bit rate (Mehtod 1)

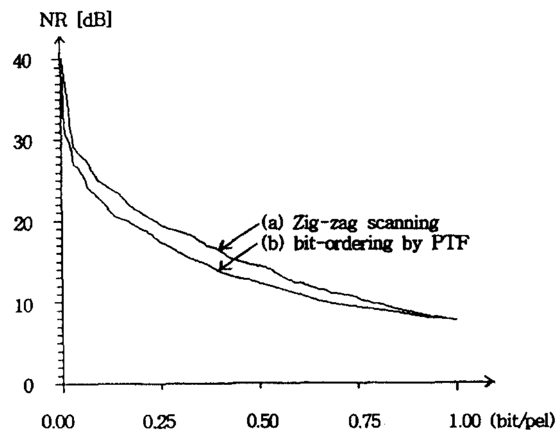
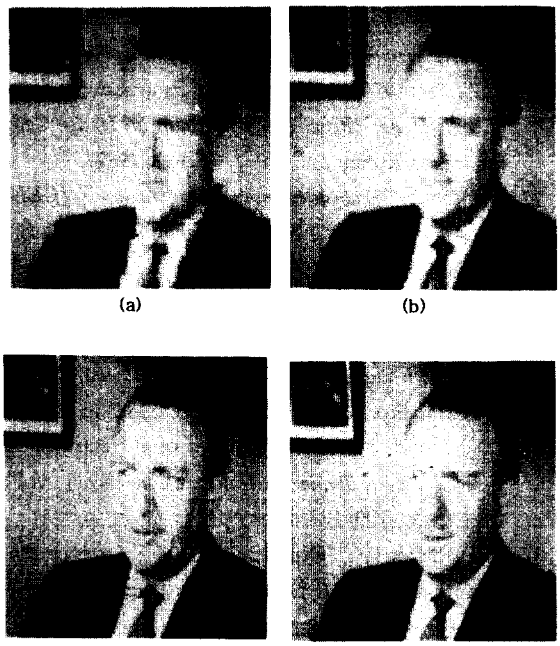


Fig. 4. NR according to bit rate (Mehtod 2)

$$NR = 10 \operatorname{Log}_{10} E\{[O(m,n) - Y(m,n)^2]\} \quad (6)$$

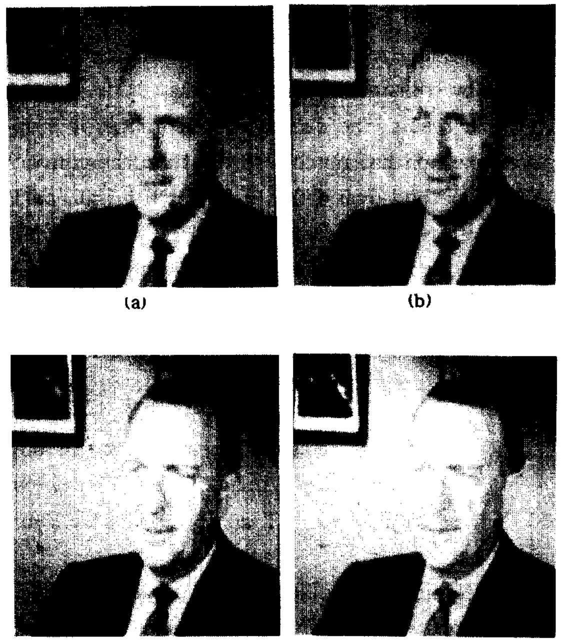
Fig. 3 and Fig. 4 present NR according to bit rate in the progressive transmission using optimum bit-ordering ith PTF. Overhead information of bit allocation and variance estimation constant is not included in both cases.



(a) (b) (c) (d)

Fig. 5. Reconstructed images using zig-zag scan method (a) 0.125[bpp] (b) 0.25[bpp] (c) 0.50[bpp] (d) 1.00[bpp]

As shown in the Fig. 3 and Fig. 4, progressive transmission using optimum bit-ordering with PTF has much less distortion in the reconstructed image than zig-zag scan transmission[2]. At the bit rate lower than 0.1 [bit/pel], the proposed methods are superior to the conventional method over 2.0-3.0[dB] in NR. The progressive transmission using Method 1 embedded quantizer is a little better than that using Method 2 in distortion. The conventional zig-zag method and the



(a) (b) (c) (d)

Fig. 6. Reconstructed images using the proposed method (a) 0.125[bpp] (b) 0.25[bpp] (c) 0.50[bpp] (d) 1.00[bpp]

proposed method have same performance at 1.0 [bit/pel] because of all the bits of coded image being transmitted.

As shown in Fig. 5 and Fig. 6 image reconstructed by progressive transmission using optium ordering with PTF are perceptually better than those by zig-zag scan transmission at the receiving of a few bits of the coded bits. At the same bit rate, edges of proposed method are presented more clearly in the reconstructed image than the conventional zig-zag scan transmission. The reconstructed images in Fig. 5 and Fig. 6 are obtained using the embedded quantizer of method 1.

V. CONCLUSION

Progressive transmission using optimum bit-ordering of DCT coded imgae is proposed to obtain an image having better quality at early state. For optimum bit-ordering of all the DCT coded bits, PTF is also proposed. It is the squared value of difference between reconstruction level of embedded quantizer and another reconstruction level made by transmitting one more bit.

As a result, the reconstructed image of proposed method has much less NR than the conventional method over 2.0-3,0[dB] at 0.1 [bit/pel]. Progressive transmission using optmal bit-ordering can reconstruct a better image at early state than conventional zig-zag scan of coefficients.

REFERENCES

1. K. Takikawa, "Fast progressive reconstruction of a transformed image," *IEEE Trans. on Inform Theory*, vol. IT-30, pp. 111-117, Jan. 1984.
2. K. Ngan, "Image display techniques using the cosine transform," *IEEE Trans. on Acoust, Speech, Signal Proc.*, vol. ASSP-32, no.1, pp. 173-177, Feb. 1984.
3. L. Wang and M. Goldberg, "Progressive image transmission by transform coefficient residual error quantization," *IEEE Trans. on Commun.*, vol.36, no.1, pp. 75-87, Jan. 1988.
4. M. Goldberg and L. Wang, "Comparative performance of pyramid data structures for progressive image transmission," *IEEE Trans., on Commun.*, vol.39, no.4, pp. 540-547, April. 1991.
5. L. Wang and M. Goldberg, "Reduced-difference pyramid : A data structure for progressive image transmission," *Optical engineering*, vol.28, no.7, pp. 708-716, July. 1989.
6. K. Tzou, "Progressive image transmission : A review and comparision of techniques," *Optical engineering* , vol.26, no. 7, pp. 581-589, July 1987.
7. K. Knowlton, "Progressive transmission of gray-scale and binary picture by simple, efficient and lossless enconding scheme," *Proc. of IEEE*, vol.68, pp.885-896, July 1980.
8. P. Burt and E. Adelson, "The Laplacian pyramid as a compact image code," *IEEE Trans. on Commun*, vol. COM-31, no.4, pp. 532-540 Apr. 1983.
9. S. Tanimoto, "Image transmission with gross information first," *Comput. Graph. Image Proc. 9, 72-76, 1979.10. Y. Yasuda, "Progressive coding of still image," Proc. Int. Workshop on Image Coding, Seoul Korea, pp. 129-177, Aug. 1987.*
11. *K. Tzou, "Embedded max quantization," IEEE Int. Conf., Acoust., Speech, Signal Proc.*, ICASSP' 86, pp. 05-508, 1986.
12. K. Tzou and S. Elnahas, "Bit-sliced progressive transmission and reconstruction of transformed image," *IEEE Int. Conf., Acoust., Speech, Signal Proc.*, ICASSP' 86, pp. 533-536, 1986.
13. S. Lloyd, "Least square quantization in PCM," *IEEE Trans. on Imformation Theory*, vol. IT-28, pp. 129-137, Mar. 1982.
14. J. Max, "Quantization for minimum distortion," *IEEE Trans. on Information. Theory*, vol. IT-6, pp. 7-12, March 1960.
15. N. Jayant and P. Noll, *Digital Coding of Waveform*, Englewood Cliffs, NJ; Prentice-Hall, pp. 535-562, 1984.
16. Y. Shim and T. Huang, "On optimum bit allocation in block quantization," *Int. Symp. on the Information Theory*, Ann Arbor, Michigan, pp. 127-134, Oct. 1986.

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