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Fast ITTBC using Pattern Code on the Subband Segmentation

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ABSTRACT

Iterated Transformation Theory-Based Coding (ITTBC) suffers from very high computational complexity in encoding phase. This is due to its exhaustive search. In this paper, our proposed image coding algorithm preprocess an original image to subband segmentation image by wavelet transform before image coding to reduce encoding complexity. A similar block is searched by using the 24 block pattern codes which are coded by the edge information in the image block on the domain pool of the subband segmentation.

As a result, Numerical data shows that the encoding time of the proposed coding method can be reduced to 98.82% of that of Joaquin's method, while the loss in quality relative to the Jacquin's is about 0.28dB in PSNR, which is visually negligible.

Keywords: ITTBC, wavelet transform, subband, pattern code, domain, range, quadtree

1. INTRODUCTION

Digital image coding techniques are very important in various areas for efficient storage or transmission of images. It is noticed that the encoding method of image data by fractal and subband using the wavelet theory as the efficient encoding technology with preserving the image loss and brightness.

To contract image data, so far suggested representative coding methods are transform coding, vector quantization, fractal coding and wavelet transform coding¹ that is being studied recently. A fractal scheme introduced by Mandelbrot² at first and applied gradually to image coding by M. Barnsley³ and applied by using Iterated Function System (IFS) by Jacquin⁴ and Fisher⁵, which include a self-similarity in the given image. ITTBC^{6,7,8} method uses that all images have large or small self-similarity in those images. The essence of the compression process is the pairing of each range block to a domain block

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such that the difference between the two, under an affine transformation, is minimal. This involves a lot of searching.

ITTBC method could typically be compressed to high compression ratio while still looking pretty good. Nonetheless, this method has the problem of computation burden because searching time is required to obtain the domain block which is adequate to a range block.

In this paper, reducing the searching time for the similar block while keeping the high compression ratio and the high quality of the decoding image, our proposed image coding method at first allows of subband segmentation⁹ of original image by wavelet transform using Daubechies's filter, second decomposes all subband images to quadtree multiresolution blocks according to image information, third codes each quadtree multiresolutioned domain block according to the pattern of the edge information in the block and forth searches adaptively similar domain block on the low frequency band which the important image information is compacted in.

2. SUBBAND SEGMENTATION BY WAVELET TRANSFORM

The basic concept of the wavelet transformation means expressing a certain function f by superimposing the wavelets. Wavelet transform is to base an analysis on one function $\Psi(x)$ that would be well localized in both time and frequency. This function was then dilated and translated to form a family of analysis functions. There are normalized as fellows

$$\Psi_{a,b}(x) = \frac{1}{\sqrt{a}} \Psi\left(\frac{x-b}{a}\right) \quad a, b \in R \quad (1)$$

Where a is a scale parameter by which the wavelet is contracted and expanded, and b is a translation parameter. Since a is a scale parameter, the scale of the basis wavelets can be controlled. And the basis wavelets can be translated anywhere by varying b .

Discrete wavelet transform is discovered by carefully choosing the analysis function and by taking $a = 2^{-j}$ and $b = 2^{-j}k$ ($j, k \in Z$) as discrete values for the parameters a and b , that one could obtain orthonormal bases for $L^2(R)$ of the type

$$\Psi_{j,k}(x) = \frac{1}{\sqrt{2^j}} \Psi(2^j x - k) \quad j, k \in Z \quad (2)$$

and that the expression

$$f = \sum_{j,k \in Z} \langle f, \Psi_{j,k} \rangle \Psi_{j,k} \quad (3)$$

for decomposing a function in these orthonormal wavelets covered in many function spaces. An image is divided into four subbands by wavelet transform. We can have a multiresolution as a result of iteration of wavelet transform.

3. PROPOSED METHOD

We propose the fast ITTBC algorithm that can reduce the encoding time and keep high compression ratio and faithfulness of the decoded image, which use the adaptive searching method by the block pattern code and band limitation on the subband segmentation.

3.1 Adaptive Multiresolution on the Subband Domain Pool

In the field of image coding algorithms, the wavelet transform method which get high compression ratio can control the data information for each band divided by the weighted rate because input image is decomposed to multiresolution by visual sensibility. The subbands using in this paper by the wavelet transform can be shown by figure 1.

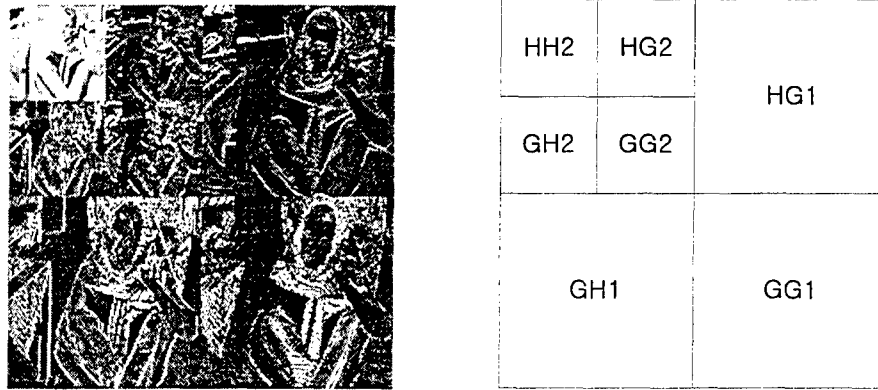


Figure 1. Subband segmentation by 2 level wavelet transform

First, we construct the decomposed subband image by 2 level wavelet transform. Second, we divide adaptively the wavelet transformed subband(HH2, HG2, GH2, HG1, GH1) into three step sub-blocks based on quadtree partitioning as shown in table 1.

The HH2 band having a large amount of image information can be divided into the first step (8 by 8) blocks. If the image information(8 by 8 blocks) exceed the setting threshold value, it means the block is dividable into the smaller blocks such as the second step (4 by 4)blocks, the third (2 by 2)blocks. In HG2 and GH2 band having a lot of vertical and horizontal image information, they can be divided into the first step (16 by 16)blocks. According to the amount of information, they can be divided into low-step blocks such as the second step (8 by 8)blocks and the third step (4 by 4)blocks. Also, the HG1 and GH1 band can be divided into the first step (32 by 32)blocks. According to the amount of information and they can be divided into the low-step blocks such as the second step (16 by 16)blocks, the third step (8 by 8)blocks. In diagonal image band GG1 and GG2 having a little amount of information, we can get the average image information.

Table 1. Design specifications of the proposed coding system

Original Image	
Name	Barbara
Resolution	256
Gray levels	256
Subband Segmentation	
Wavelet transform level	2 level WT
Filter	Daubechies's
Encoding Specifications	
Range partition type	3 step multiresolution quadtree
Range blocks	HH2 : 8 by 8, 4 by 4, 2 by 2 HG2, HH2 : 16 by 16, 8 by 8, 4 by 4 HG1, GH1 : 32 by 32, 16 by 16, 8 by 8 GG2, GG1 : Average
Domain blocks	32 by 32, 16 by 16, 8 by 8, 4 by 4

Therefore, each subband can be divided adaptively into multiresolution quadtree partition according to the amount of information. That is, most of energy is concentrated on the low resolution band. If the band has high resolution, there is small energy. By using this, we can minimize the range blocks and progress the compression ratio.

3.2 Block Pattern Code

After partitioning each subband until the adaptive third step multiresolution on the wavelet transformed image with edge information, we take an image information to the mean value for the first step domains.

In the second step and the third step quadtree partition domain pool, all blocks are broken up into four equal-sized sub-squares and taken to the mean values for each block. And it is lined up to a few mean values and coded for the block pattern. Shown in Figure 2.

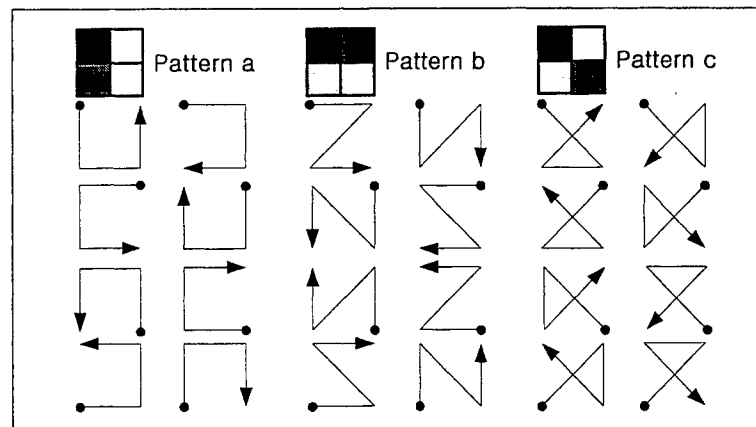


Figure 2. Block pattern code

If we code the domains by the proposed block pattern in advance according to the orientation of the edge information on

the subband segmentation, we can limit the searched domain pool into the each resolution and determine the similarity both ranges and domains on the domain pool according to the orientation index. Therefore, the range blocks are efficient to a search similar domain block because of searching for pattern code.

4. SIMULATION AND RESULTS

We estimated the fast ITTBC algorithm using pattern code on the subband segmentation compared with the result of the ITTBC method using the geometric transform proposed by Jacquin's ⁴. An original digital image "barbara"(gray level : 8 b/pixel, size : 256 by 256) shown in figure 3 was used in encoding and decoding.



Figure 3. "barbara" original image

We use criterion, such as *PSNR*(Pick Signal to Noise Ratio) of formula 4 which represents original image or not and *bit rate* of formula 5 which can evaluate compression ratio according to image coding method proposed in this paper.

$$PSNR = 10 \log_{10} \frac{255^2}{\left\{ \sum \frac{(OPV - DPV)^2}{(nB)^2} \right\}} \quad (4)$$

OPV: Original Image Pixel Value

DPV: Decoded Image Pixel Value

n: block number, *B*: block size

$$bit \ rate = \frac{N_1 A_1 + N_2 A_2 + N_3 A_3}{(nB)^2} \quad (5)$$

N₁: the Number of first step blocks

N₂: the Number of second step blocks

N₃: the Number of third step blocks

A₁: Amount of first step block data

A₂: Amount of second step block data

A₃: Amount of third step block data

Table 2 shows that the encoding time of the method proposed in this paper can be reduced to about 99.82% of that of Jacquin's method, while the decoded image quality have above $PSNR$ 34[dB]. And the proposed method which performed limited domain searching method and block pattern code can reduce the 10% searching time compared with full searching wavelet domain, as the difference of the decoded image between the full searching method and the proposed method for each band is $PSNR$ 0.05[dB].

Table 2. Comparison of coding performance

	Jacquin's method	Full search & nocode	Proposed method Limited search & code
Enc. Time[s]	2327	40	4
	-	98.28%	99.82%
		-	10%
Ranges	16384	1423	1423
SNR[dB]	28.12	28.09	28.05
PSNR[dB]	34.58	34.35	34.30
Bit rate[bpp]	3.1	0.36	0.36
	-	88.38%	88.38%

The compression ratio of the method proposed in this paper was also enhanced compared to Jacquin's method using the original image without preprocessing. We can code image information of the band with high resolution for high compression ratio. This is the reason that the efficient image coding can be produced at the band with high energy resolution.

Figure 4 and Figure 5 shows each decoded image using Jacquin's method and the method proposed in this paper, which are almost similar.



Figure 4. Decoded image using Jacquin's



Figure 5. Our decoded image

5. CONCLUSION

In this paper, we propose the efficient image coding method by fast ITTBC algorithm using the 24 block pattern codes which are coded by the edge information in the image block on the subband segmentation, in order to improve the problem which the present ITTBCs have.

Compared with Jacquin's method, the proposed method in this paper can take the improvement of 99.82% searching time on condition that the decoded image quality should be maintained to $PSNR$ 34[dB], and the compression ratio can be improved to 88.38%. But it caused a little loss in quality of the decoded image because of the error by selecting the pattern of the blocks for the distinction of the similar blocks. We will enhance the image loss in quality if we improve the code for the block character.

We proved that the similar block searching time can be reduced by block pattern code and that the decoded image quality and the compression ratio can be improved simultaneously by adaptive multiresolution image partitioning on the subband segmentation.

REFERENCE

1. M. Antonini, M. Barlaud, P. Mathieu, and I. Daubechies, "Image Coding using wavelet transform," *IEEE Trans. Image Processing*, vol. 1, no. 2, pp. 205-220, April 1992.
2. Benoit B. Mandelbrot, *Fractal Geometry of Nature*, Academic Press, 1988
3. Michael F. Barnsley, *Fractals Every where*, W H Freeman & Co, 1988
4. A. E. Jacquin, "Image Coding Based on a Fractal Theory of Iterated Contractive Image Transformation," *IEEE Transactions on Image Processing*, Vol. 1 No. 1, pp. 18 - 32, 1992.
5. Y. Fisher, *Fractal Image compression : Theroy and Application*, New York, 1994
6. M. Kawamata, ea. at. 1, "A Fast Coding Algorithm for Iterated Transformation Theory-Based Coding by Multi-

resolution Tree Searching," *The Journal of Electronic Information Communication Institute*, Vol, j78-A No. 2, pp. 253 - 260, 1995.

7. S. S. Koh, C. H. Kim, "A Fast Image Coding for Iterated Transformation Theory Based Coding Using Codebook and MRS(Multi-resolution Random Searching)," *ACCV'95*, Vol. 1 of 3, pp. I-434-I-438, 1995.
8. G. S. Cho, C. H. Kim, "Fractal Image Coding Method using Adaptive Pattern Code and MRS," *Basic Science and Engineering*, Vol. 1, No. 2, pp. 1029-1033, 1997.
9. T. A. Ramstad S. O. Aase, J. H. HusØy, *Subband Compression of Images : principles and examples*, ELSEVIER SCIENCE B. V., 1995.