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AN IMPROVED IMAGE COMPRESSION ALGORITHM BASED ON EMBEDDED ZEROTREE WAVELETS TRANSFORM

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ABSTRACT

After analyzing the basic theory of embedded zerotree wavelet (EZW) coding algorithm, this paper brings forward an improved method which rounds down the wavelet coefficients and sets the coefficients appearing more frequent as zero, so as to reduce scan frequency in algorithm and save the storage space. Experimental results show that this algorithm improves the coding efficiency on the one hand; and on the other hand the quality of reconstructed image is also not significantly decreased.

Keywords: *Frequency, Image compression, Wavelet coefficients, Embedded zerotree wavelets (EZW)*

1. INTRODUCTION

In recent years, with the popularization of multimedia application and the development of digital video technology, as well as the increase of image browsing and transmission in internet, the demand for image processing technology is more and more high, to a picture, the image processing includes: image compression, image enhancement, and the restoration of image noise etc. It is very important as far as possible to reduce the image storage space in the process of image collection, storage and transform. Therefore, the improvement of current image compression technology has become the important problem in current information era to be resolved. Wavelet image compression coding with the advantages of its high compression rate and higher quality of image restoration, makes it have great application value and broad prospect in the image compression field.

Embedded Wavelet Zerotree (EZW) coding method well realizes these thoughts; it is the one of the most outstanding image encoder based on the wavelet transform. But wavelet zerotree coding is not perfect, the improvement on little wave zerotree algorithm has become the focus of research in recent years. This paper mainly discusses zerotree quantitative theory in the EZW algorithm, through the analysis and experiment it is found the algorithm still has some problems, an improved scheme is put forward only to the quantitative part.

2. EZW CODING ALGORITHM

In 1993 J.M. Shapiro proposed a kind of high-efficiency wavelet image compression algorithm, which was called embedded wavelet zerotree algorithm[1-4], the coding is being recognized as a very effective image coding algorithm in public, in current which is thought as one of the best method in the field of static image transformation compression coding. The bit in the bittorrent obtained from this algorithm is sorted according to the importance of coefficients. The coder can end coding at any time at any point with this algorithm, which will make coding accurately reach the expected goal of the bit rate, and at this moment it still can produce excellent image effect, the characteristics of this algorithm does not require the drill, prior storage of formats streaming, and any earlier stage knowledge about image source.

In this paper, section 2 introduces the classical EZW encoding algorithm, section 3 presents a new improved EZW coding algorithm, simulation experiment are conducted in section 4, in the section 5, the conclusion is this improved algorithm is feasible in the aspect of increasing compression efficiency, and the quality of image reconstruction has no significant decline.

2.1 The Ideological Characteristics of Encoding Algorithm

A piece of image does not compress the original image after wavelet transformation, but the energy of the whole image is redistributed, and carrying on

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the compression must also be quantitatively and entropy coding. In general, in the process of wavelet image compression quantification is one of the most crucial parts, it preferably organizes the wavelet coefficients of image to realize effective compression; entropy coding is forming wavelet coefficients coding after quantification to output bittorrent.

Wavelet zerotree coding is a simple and effective image coding algorithm, the bit of bit stream in this algorithm is according to the importance to sort, it mainly uses the characteristic of wavelet coefficients, well realizes the embedded function of the image coding.

Algorithm can roughly consist of three processes: zerotree forecast, looking for zerotree structure coding important diagram, successive approximation quantification. Simply, zerotree structure is a father factor (here mentioned coefficients are all wavelet coefficients) with tree structure which has four sub-coefficients. And these sub-coefficients have four sub-coefficients respectively, and so on. From father to son in a zero tree the absolute value of each coefficient is in decline trend, this is one of the most important features of EZW algorithm. For an unimportant wavelet coefficient, all of wavelet sub-coefficients will also not important, and this branch is convinced that does not contain any important information. In this way, the whole tree structure will be encoded as a single symbol, so as to achieve the purpose of data compression. The specific process is shown in figure 1 below.

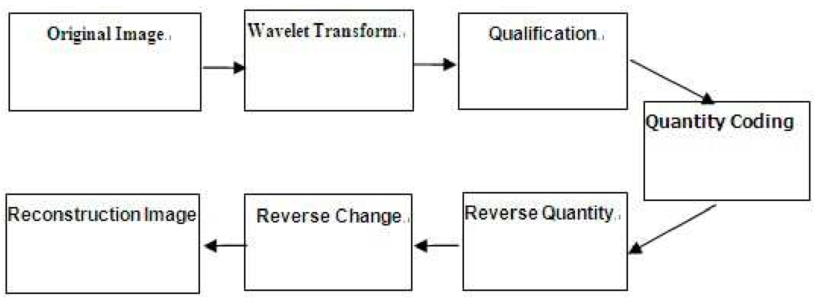

Figure 1. The Reconstruction Process Of Original Image.

In coding algorithm, there are two definitions needing to make clear:

The embedded code refers to the low bit encode output by encoder embedded in the start part of code streaming, that is, from the start point of embedded streaming to some position after this period of streaming is picked out, it equivalents to a code streaming with lower bit rate, it can decode and reconstruct the whole image, comparing with the original code streaming, the image decoded by this part of streaming has lower resolution and complete image effects.

Zerotree refers to under a given threshold, the coefficient value of root node and all its descendant nodes are invalid values, this root node is called zerotree root. The zerotree root refers the tree starting from the root node is zero tree, and at the same time the zerotree is not a subset of bigger zerotree, that is, the node is called zerotree root, its father node is not zerotree root.

In EZW algorithm, the realization of the embedded code flow is implemented by zerotree structure combing with successive approximation transmission. The algorithm uses the method of zerotree quantitative successive approximation, makes full use of correlation among the sub-bands of image wavelet coefficients, low bit rate has high signal-to-noise ratio. The basic idea of zerotree quantification algorithm is using the zerotree data structure while quantifying wavelet coefficients, to make full use of the time-frequency locality of wavelet transform and the correlation among sub-band of mining transform coefficients. The coding of this algorithm is according to Z type to do successive scan, in a given threshold value T, each wavelet coefficient is divided into the positive important coefficient POS (P), the negative important coefficient NEG (N), isolated zero IZ(Z) and zerotree root ZTR (T). In a given threshold value the algorithm experiences two processes: the main scanning and vice scanning, and then the threshold value drops to 1/2, in the condition of lower threshold value, which realizes the successive approximation embedded coding.

2.2 The Process of Coding Algorithm

1) Determine the initial threshold, T_0 is used to presents initial threshold: $T_0 = 2^{floor\{\log 2(\max(|r(i,j)|))\}}$, in the expression, floor {} represents that rounded down

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to the integer, r (i, j) represents the wavelet coefficient value, and later for each scan, the threshold is cut by half.

2) Form main table according "Z" scanning sequence, again according to amplitude encoding process form vice table, the scan process is shown in figure 2.

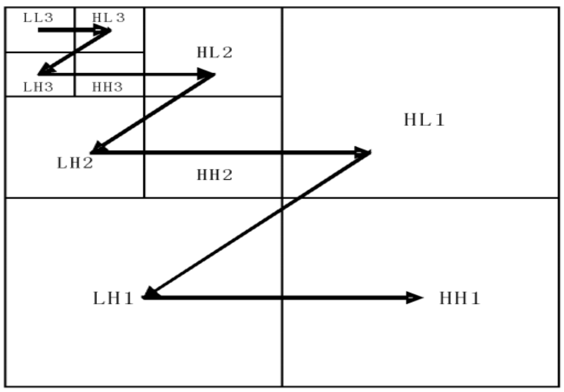

Figure 2. "Z" Type Image Scanning.

The main scan is used to complete the following tasks:

According to the output code flows after scanning wavelet coefficients, suppose coefficient is X[i], the threshold is T, it will follow the following rules:

If $X[i] > T$, the output is P;

If $X[i] < -T$, the output is N;

If $|X[i]| < T$, and there is an important coefficient in the offspring coefficient, then output Z;

If $|X[i]| < T$, and there is no important coefficient in the offspring coefficient, then output T;

The positive and negative important coefficient will be extracted, take its absolute value and put in the vice table.

The position of important coefficient in the main table is set to zero.

Auxiliary scanning is used to complete the following tasks:

For the important coefficient after main scan to do refining coding, according to the coefficient in vice table to output 0 or 1, specifically follow the rules:

When the absolute value of important coefficient is located between T~3/2T, it is represented as 0 or 1;

When the absolute value of important coefficient is located between 3/2T~2T, it is represented as 1 or 0;

When the threshold value reduces to 1, according to the code stream output by main scan and vice scan all the coefficient value can be presented.

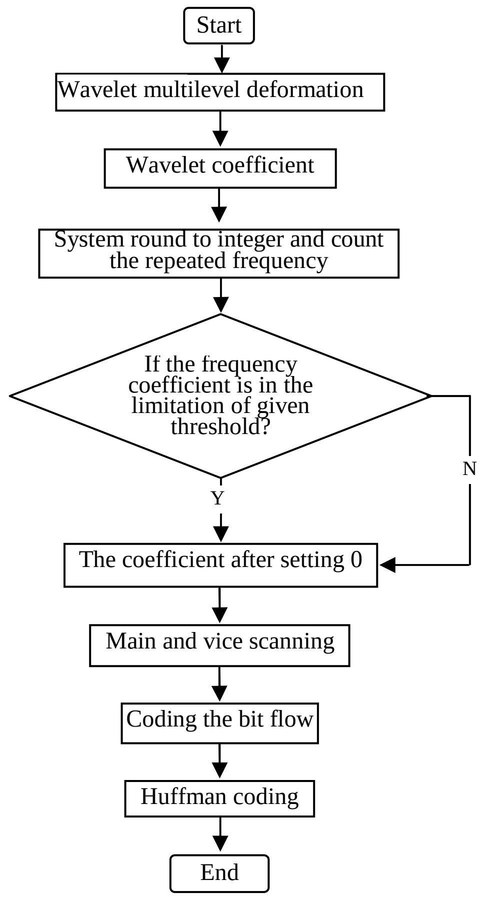

Figure 3. The Improved Algorithm Code Flow Chart.

Finally the output code flow needs entropy coding, the arithmetic coding is generally adopted. Because each round of threshold is different, finally in the vice table, the non-zero point listed in the preceding is more relative important than behind. In this judgment there exist only four kinds of symbols: positive value, negative value, zero root, and isolated zero, so that it can realize the compression of bits. These four kinds of symbols and the symbol in nonzero numerical range use entropy coding in accordance with the size of probability to realize compression, to achieve the requirement of low bit rate. Since in each sub-band

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the meaningful coefficient is according to the principle from father system to child system and the priority of important value arranged in vice table, so according to the compression requirement to obtain important value automatically.

1)According to the importance principle to adjust the order of amplitude in the vice table.

2)The values in main table and vice table are sent to entropy encoder to do adaptive arithmetic coding output.

3)While reaching target bit rate the coding stops, otherwise, repeat steps 2), 3).

3. IMPROVED CODING ALGORITHM

The above description of zerotree quantitative method, EZW adopts the same quantitative method as other sub-graph for the lowest-frequency sub-graph. After wavelet transform, the lowest frequency sub-graph contains most of the energy of original image, and the coefficient amplitude value is much bigger than other value of sub-graph coefficient.

Through the study, we find that in high compression ratio, the original zerotree quantization can make the low frequency sub-graph get much loss, and difficult to guarantee in low bit rate to ensure the quality of image restoration. In addition, this part of the code almost does not affect the entire image compression ratio, but its smaller loss will cause big impact to the whole image recovery quality.

According to the EZW theory, for high frequency sub-graph using zerotree structure quantitative, in order to achieve the purpose of bit rate and signal-to-noise ratio being variable, threshold T value gradually decreases according to the negative power level of number 2, while T reduces once, the high frequency sub-graph needs to do zero tree classification, the master table and the vice table are respectively treated so that it is relatively complicated, and the encoding time is long, therefore, we needs to study the improvement method.

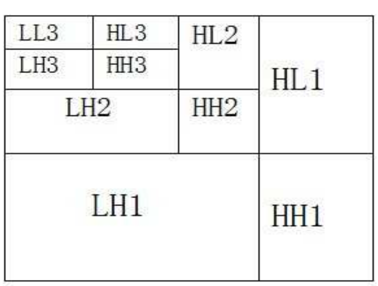

Figure 4. The Frequency Matrix Diagram

Due to the energy of image after wavelet transform mainly concentrates in the low frequency sub-graph, so the improvement method is to retain the LL3 (the lowest frequency coefficient) matrix, it is a 32×32 phalanx, and will not participate in zero quantification, but adopts the scalar quantizer, quantization step takes 1 to ensure that this part of sub-graph in using adaptive arithmetic coding as possible as lossless.

For high frequency sub-graph the quantization of zerotree structure is still used. Improved method is, according to the requirements of the compression ratio, the high frequency wavelet coefficients of the sub-graph only for a zero tree coding, in does not affect the overall image compression ratio under the condition of the improve coding efficiency.

In order to consume additional bits, due to the isolated zero emerging is because the j-th layer sub-graph is meaningless, but in its sub-generation there is non-zero. We try to restore the quantitative value of isolate zero, and coding with the non-zero points, this time, the entire high frequency sub-graph coefficient is only have two classification: non-zero point, zero root. In this way image distortion is effectively reduced, at the same time the coding efficiency is also improved.

When the original algorithm do quantification in the tree structure, the value of threshold is according to the negative power level to reduce gradually, and every reduce once, the high frequency sub-image is need to do zerotree classification, the main table and vice table are respectively do multi zero searching and judgment processing, which will consume a lot of time, and compression effect is limited. After image signal does multistage wavelet transform, the most of the energy is focused in the low frequency part, and in low frequency level wavelet coefficients shows larger amplitude, which is far bigger than other wavelet coefficients with high frequency sub-band, reflects the main characteristics of image signal, and plays a key role to the restore of image quality.

The improved method proposed in this paper is based on wavelet transform coefficients for related statistical analysis, there exist a number of repeated coefficients and most of them are focused in the high frequency part after wavelet coefficients round down the integer. In the premise of keeping the quality of reconstructed image almost same, these non-important coefficients unifying into zero can reduce the scanning number in the given adjustment frequency range within high and low threshold, so

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as to improve the coding efficiency. The quantified coefficients adopts Huffman encoding in order to achieve the purpose of efficient compression to do prejudice compression, the flow chart is illustrated in figure 3 below.

The process is as follows:

(1)Suppose after the multi-level wavelet transform, the wavelet coefficient is C (i, j), its round down integer is R (i, j) = |C (i, j)|;

(2)Statistics the frequency of repeat coefficient N (N is the number of duplicate values appearing in coefficients) in the coefficient matrix after taking integer;

(3)Set the threshold range [M, N] of the zero coefficient (based on image quality to do adjustment, in the experimental simulation it is [-24,24]), and determine if the repeated frequency coefficient is in the range of given threshold, if it is then set to zero, and vice versa does not change;

(4)Execute main and sub scanning, quantization and Huffman coding to formative changed wavelet coefficient matrix.

4. THE SIMULATION RESULTS

If you are using *Word*, use either the Microsoft Equation Editor or the *MathType* add-on (http://www.mathtype.com) for equations in your paper (Insert | Object | Create New | Microsoft Equation *or* MathType Equation). "Float over text" should *not* be selected.

This simulation EZW coding algorithm gives an example of bitmap (Figure 5, bmp format, wavelet basis is bior4.4, wavelet transform is eight level) with resolution Lena (256×256) on the desktop which main clock is 2000 MHz to achieve the improved algorithm's simulation using Matlab. Here are the images comparisons of the experimental reconstruction between the original EZW algorithm and improved EZW algorithm, Figure 6 and Figure 7 present the comparison of experimental performance indexes shown in Table 1.

Figure 5. Original Image Lena (256 × 256).

Figure 6. Lena Reconstructed Image Of Ezw Algorithm.

Figure 7. Lena Reconstructed Image Of Improved Ezw Algorithm.

Table 1. The Performance Comparisons Between Original And Improved Ezw Algorithm

Name of algorithm	Coding rate /bpp	Total bit /bit	Peak value signal-to-noise ratio /dB
EZW algorithm	1.071 25	548	27.76
Improved EZW algorithm	0.128 75	66	27.75

Through the above comparison, the improved EZW algorithm has better compression effect than original EZW algorithm. The image coding bits is almost 1/8 of the original EZW algorithm; meanwhile the image reconstruction quality changes little.

5. CONCLUSIONS

This paper presents an improved embedded zerotree coding algorithm (IEZW) about compression effect of images. This algorithm through analysis of coefficients characteristics after the wavelet transform, deals with the duplicate data in wavelet coefficients, makes the number of scans reduced, and thus shortens the output code streaming, according to the encoding and the requirements to restore the image quality to end

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coding at any time, which has good compression effect. The experiment proves this improved algorithm is feasible in the aspect of increasing compression efficiency, and the quality of image reconstruction has no significant decline.

REFRENCES:

[1] Jielong Chen. Jing Yang. Improved Embedded Zerotree Coding Algorithm. *Computer Engineering*, 2010, 36 (2):209-213.

[2] Lei Zhao, Hongye Xue. Research of Image Registration Method Based on Wavelet Decomposition and the Maximum Mutual Information. *Shanxi Institute of Technology: Natural Science*, 2010, 26 (3):22 -26.

[3] Fan Zhang, Guozhong Zhu. Based Pan-Fibonacci Web Images Fast Rendering. *Modern Electronic Technology*, 2009, 32 (16):103-106

[4] Luwei Li. Medical Image Compression Techniques Based on Wavelet Transform. *Computer and Digital Engineering*, 2009, 37 (2):136-138.

[5] Tao Cheng. Embedded Image Coding Using Zerotree of Wavelet Coefficient. *IEEE Trans on Signal Processing*, 1993, 41(12): 3445-3462.

[6] Yankui Sun. *Wavelet analysis and its application*, Beijing: Mechanical Industry Press, 2005.

[7] Gonzalez. *Digital Image Processing*. Qiuqi Ruan, translation. The 2nd version. Beijing: Electronic Industry Press, 2005.

[8] Bing Xue, Xiaofeng Gu. *Embedded Zerotree Wavelet Coding Algorithm and Applied Research.* Chengdu: University of Electronic Science and Technology, 2008.

[9] Yizhen Zhang, *Visual C++ Realize MPEG/JPEG knitting Decoding Technology.* People's post and telecommunications university press, 2002 (11): 70 131.

[10] Chengqian xing. *Wavelet analysis algorithm and application.* Xi'an Jiaotong University Press Club, 1998 (5): 178 204.

[11] Shaprio J. *Embedded image coding using zerotree of wavelet coefficient.* IEEE Transactions on signal Processing, 1993, 41 (12):

[12] Cast leman Kr. *Digital image processing.* Beijing: electronic publishing industry. Club, 2002, 88, 105.