An Improved SPIHT Format for Image Transmission

Li-Der Jeng
Department of Electronic Engineering
Chung Yuan Christian University, Chung-li, 320 Taiwan

Yuan-Nung Liu
Department of Electronic Engineering
Chung Yuan Christian University, Chung-li, 320 Taiwan

Yuan-Hsiang Chang
Department of Information and Computer Engineering,
Chung-Yuan Christian University, Chung-Li, 320 Taiwan

Abstract :

In this paper, we propose a new image compression algorithm called improved-ISPIHT, based on wavelet domain method. We apply this algorithm to RS coded FH-SS system for image transmission. Compared to the set partitioning in hierarchical trees algorithm (SPIHT) and modified-SPIHT (MSPIHT), the ISPIHT has better compression efficiency and lower distortion. Simulation results show that the performance of our system is better than those use the standard SPIHT or MSPIHT algorithm.

Keywords- *SPIHT; PBNJ; FH-SS; RS code; ISPIHT*

I. INTRODUCTION

Frequency hopping technology was originally applied to the military communication, it was also adopted for the common communication systems in recent years because that frequency hopping system has excellent anti-interference characteristics. To enhance the performance of communication system, channel coding technique is a good choice for the frequency hopping system [1] [2]. The anti-interference performance analysis of FH-SS system against PBNJ is widely studied [3] [4]. However, most of those researches [1] - [4] focus on the analysis of error rate, only few of them consider the characteristic of the transmitted data. Li-Der Jeng and C. H. Su [5], employed the correlation among the image data and channel coding to improve the image transmission quality. However, the data format they considered is the uncompressed image whose transmission bandwidth efficiency is much less than the compressed one. The common image compression technology is the Set Partitioning In Hierarchical Threes (SPIHT) algorithm, and this method is proposed by A. Said et al. [6]. This compression algorithm based on wavelet domain divides the images into high and low frequency images, which are performed with the Embedded Zero-tree Wavelet (EZW) coding [7]. The characteristic of the algorithm is low operation complexity, low complexity in equivalent encoding and high compression efficiency. However, the coded format is not a good choice for image transmission. Thus, if the data is to be interferenced, it is usually easy to fail at the data decompression step.

To improve this defect, Chao-Ping Huang et al. [8] proposed the MSPIHT(modified-SPIHT) algorithm for coded FH-SS system. The main idea of the MSPIHT is to change the compression format so as to make it suitable for the Unequal Error Protection (UEP) mechanism. Due to the compressed information is more sensitive to errors than uncompressed one, and the importance of data are different among for different parts, applying UEP technique is now becoming a common solution for compressed image transmission. The main idea of UEP is to transmit maximum effective information with lowest code rate. That is, the UEP technique protects important parts of data with more powerful code; and protects the other bits with shorter code, and its affect of the information distortion will limited. Because the information content of the high frequency pixel's is less important. The MSPIHT algorithm put the important information on the file header firstly, then use the powerful code to protect it and go through the interference. In order to increase transmission efficiency, we want to reduce the compression data; and the pixel values after MSPIHT can not effectively restore the original pixel values, the restored image and the original have significant differences. Therefor, we proposed a new SPIHT algorithm to increase the image quality and reduce the compressed data.

The remaining paper is organized as follows. In section II, we introduce our system architecture. Section III introduces ISPIHT methods we proposed. Section IV, simulation results are given and analyzed. The conclusion is summarized in last section.

II. SYSTEM ARCHITECTURE

The system architecture we considered is shown in Figure 1. The original image is transformed into a wavelet domain image by DWT, and the ISPIHT algorithm is utilized to compress it into a data stream. We use different kinds of RS codes with different code rates to encode this bit stream to achieve the UEP. The RS codeword is modulated by MFSK and then transmitted by SFH-SS system. The transmitted data will suffer from the interference of AWGN and PBNJ via wireless channel. At the receiver, the transmitted data will be demodulated by SFH and MFSK. After channel decoding and decompression, the received images gotten from the inverse discrete wavelet transform.

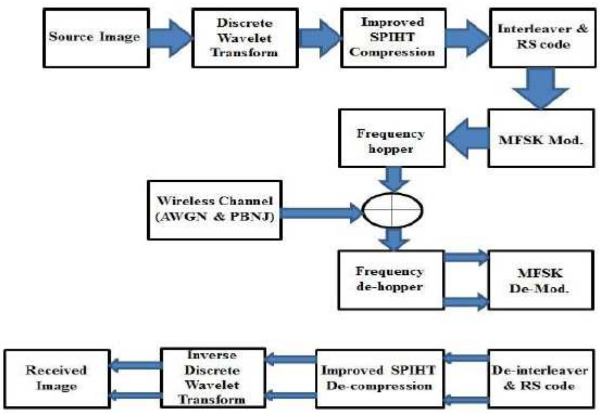


Figure 1. Block diagram of the image transmision system.

III. ISPIHT

From [6] - [8], we propose a new compression format called improved-SPIHT (ISPIHT), which take the advantage of the MSPIHT compression algorithm [8], and EZW algorithm [7]; We take the middle of the threshold value as the new threshold, then it will be closer to the original pixel value in the refining process. To enhance the image quality; and important information is concentrated to the bitstream front-end, so it easy to protect the header file.

We simply make a introduce for MSPIHT and EZW. The characteristics of the MSPIHT algorithm is put the important information after the header files, then use a powerful code to protect them. It's make sure the received image could have certain quality. But, the pixel values after MSPIHT can not effectively restore the original pixel values, so the restored image and the original have significant differences. Although the EZW algorithm's refine step can be sure the pixel value will more closed to the original image, but it's error sensitivity of the compression data is higher than the MSPIHT algorithm. Based on the above characteristics, we take their advantage which are put the important information in front of the compression data with the header files; and comput the refine value to increase the image quality. In addition to the above two points, we also improved threshold velue, it's make the pixels in the high frequency band are more closed to the original pixels.

The ISPIHT is improved from EZW algorithm, and the EZW algorithm has three concepts:

1. Zerotree: 2D-DWT structure shows that four in the last layer of the point called the point of sub-band in the lower strata of the point, which point extending out of the children and grandchildren with a tree structure to construct. If this is the more descendants with compression, you can save even more space.
2. Scan order: Discrete wavelet transform the band of the proceeds of a zigzag manner, the order of storage. Stored in the order in accordance with the most important low-frequency to intermediate frequency to the last and most important high-frequency.
3. Using threshold to split the results after the DWT into several layers, and stored it.

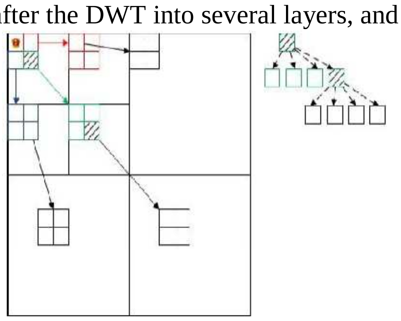


Figure 2. Relationship of the tree structure

ISPIHT (zero-tree EZW) are divided into several types to represent the i-th row and j-th column of the image coordinates *(i, j)*. Defining the symbols here:

N: Maximum coefficient of the share of the results of the DWT-bit number. Removed from maximum coefficient values, seeking the log base 2 results. ij C

$N = \log_2(\max|C_{ij}|)$, C_{ij} is the image relative position.

T_k : The most important thing on this paper is the threshold, in order to avoid the maximum value with the original SPIHT threshold difference is too large, take the middle of the two threshold values as a new intermediate value.

$$T_k = \frac{2^{N+1-k} + 2^{N-k}}{2} \quad (1)$$

The value of k is an integer increments from 0, the maximum value of k is equal to the values of N, used or class distinction; final calculation to T_k decreasing to 0 to stop.

H: After DWT, the most important coefficient.

R (Reconstruct value): The middle of the image maximum value and the threshold value.

$$R = \frac{\max(C_{ij}) + T_k}{2} \quad (2)$$

R_1 (Refine value 1): The middle of the reconstruct value and the image maximum value.

$$R_1 = \frac{\max(C_{ij}) + R}{2} \quad (3)$$

R_2 (Refine value 2): The middle of the reconstruct value and the threshold value.

$$R_2 = \frac{R + T_k}{2} \quad (4)$$

Particular attention to the lowest frequency are not descendants.

Three used to manage records in the process list:

LIP: list of insignificant pixel.

LSP: list of significant pixel.

LIS: list of insignificant set.

The introduction of the term, then the calculation process of SPIHT.

A. The ISPIHT calculation in four phases:

1. Initialization set the collection and parameters.
2. Sorting Pass, locate the important point.
3. Refinement Pass, the important point value more accurately marked out.
4. Quantization - Step Update, reduce the scanning threshold to the next stage of approximation of the original value.

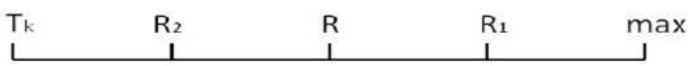


Figure 3. Illustrative:the maximum value, refining values, rebuild value and the threshold

B. The complete calculation steps are as follows:

1. Initialization:

   Calculate $n = [\log_2(\max_{(i,j)}\{|C(i,j)|\})]$.

   Set threshold as $T = 2^n$.

   Let LSP as an empty list.

   All the coordinates (i, j) ∈ H to join the LIP, and descendants part of the D type to join the LIS.

2. Sorting Pass:

2.1 All LIP coordinates (i, j) to do:

2.1.1 Output Sn(i , j).

2.1.2 . If Sn (i,j) = 1 , move (i,j) to the LSP and output symbols.

2.2 . All LIS sets (i,j) to do:

2.2.1. If it's D type

Output Sn(i,j).

if Sn(i,j)=1,Then each (k, l) ∈ O (i, j):Output Sn(k,l).

If Sn(k,l)=1, move (k,l) to the LSP and output symbols.

If Sn(k,l)=0, move (i, j) to the LSP.

If there are L (i, j), then (i, j) the change to join the LIS with L type.

If L (i, j) does not exist, (i, j) is removed since the LIS.

2.2.2 If it's L type

Output Sn(i,j)

If Sn(i,j)=1,(K, l) ∈ O (i, j) with D type to join the LIS.

(i, j) LIS removed.

Refinement Pass:

In addition to the coordinates in the latest addition to the LSP, refining LSP coordinates (i, j), output of n bits |)

, (|jiC

4. Quantization-Step Pass:

n minus 1 and return to Step 2 under a threshold to scan.

In accordance with the rules of the original SPIHT bitstream can be expressed in Figure 4, the header contains the initial threshold value $T_k = \frac{2^{N+1-k} + 2^{N-k}}{2}$ 、DWT levels, image size information, subsequent data string $T_1, T_2, T_3 \ldots$…etc respectively different the threshold value of the output of the stage .

In this paper, a new data stream content location diagram to represent , the (i, j) ∈ H output will be directly connected after the Header, and the rest of the coding results are to maintain the original output mode. It can be expressed in Figure 5.

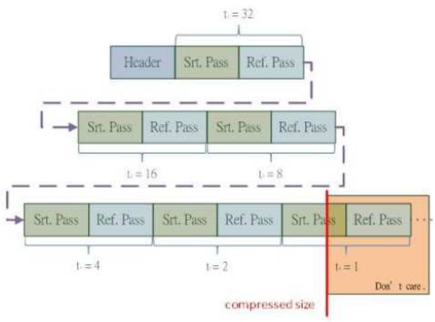
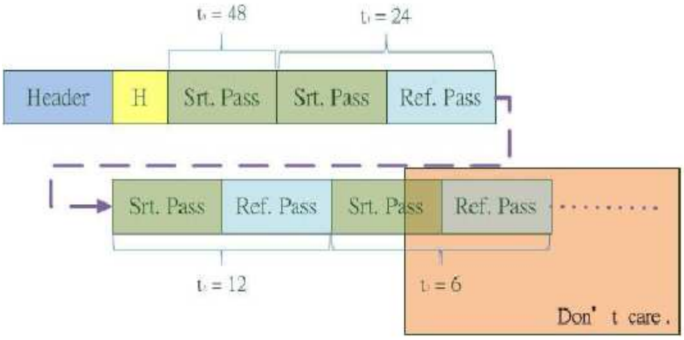


Figure 4. SPIHT output data stream content location schematic

In this paper, a new data stream content location diagram to represent , the (i, j) □ H output will be directly connected after the Header, and the rest of the coding results are to maintain the original output mode. It can be expressed in Figure 5.

Figure 5. ISPIHT output data stream content location schematic



IV. EXPERIMENTAL RESULTS

As shown in Figure 7, the original images are transmitted at 512*512, single-color 8bpp pictures. The experiment will simulate the case that the SFH/256-FSK system uses two identical images for transmission (L=2) in channels under the PBNJ environments in which the frequency band interference ratio is . The two channel codes for UEP were chosen to be (256, 130) and (32, 12) extended RS code. The (256,130) RS code is used to protect the data streams of important parts at front-end and another is used to protect other data streams.

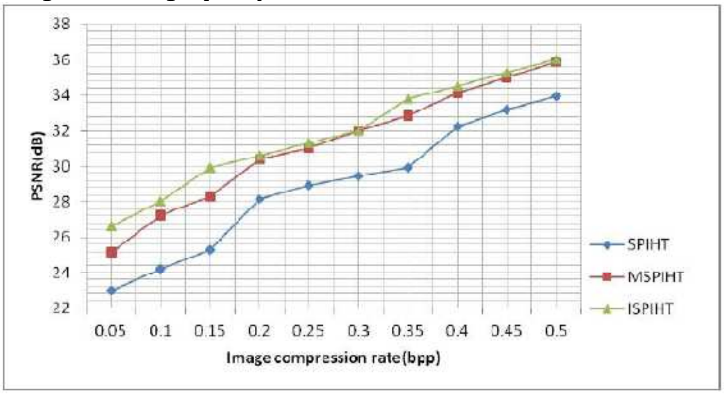
□

Figure 6. Original Image

To compare the performance difference of ISPIHT algorithm, MSPIHT algorithm and SPIHT algorithm, we used the same images and nonequivalent protection technology to carry out the simulation. We conducted 100 transmission simulations based on all the data results of the pictures, the numerical value we obtained is at least one reliable digit behind the decimal point, and then the results are summed up by the rate of large numbers. Figure 7 shows the simulation results obtained by using the same compression rates in the ISPIHT, MSPIHT or SPIHT algorithm method. And it can be found from the figure that, the PSNR value generated without adopting the improved algorithm method is low; and with the increase of compression rate, the image difference generated by the diversity combining method will become unobvious.

And we can also find from the figures that, the lower the compression rate is, the more serious the image distortion after transmission is, and the difference in images generated by the SPIHT method will be larger. However, the higher the compression rate is, the less obvious the image distortion is, and the difference in images generated by three SPIHT method will be smaller. To verify this assumption, we carried out experiments under low and high compression rates respectively and made the comparison.

Figure 7. The original image and image quality of the cactus



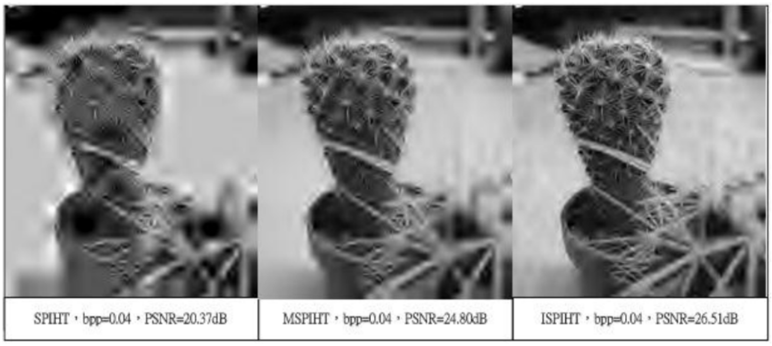


Figure 8. Comparison of Image Quality using Compression Rate 0.04

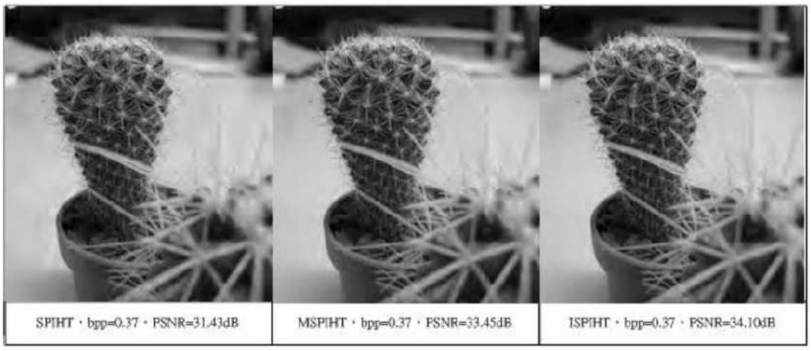


Figure 9. Comparison of Image Quality using Compression Rate 0.37

Both of the Figure 8 and Figure 9 are pictures generated through three methods by adopting in the ISPIHT, MSPIHT or SPIHT algorithm method at compression rate of 0.04bpp and 0.37bpp. It can be found from the three figures that, when the compression rate is low, the image distortion will be serious, and the difference in images generated by using three SPIHT methods will be very large. On the contrary, when the compression rate is high, the generated images will be closer to the original images and the difference in images generated by three methods is small, and it is unable to compare whether the use of the different algorithm method can effectively improve the quality of pictures. According to various experimental results, the ISPIHT algorithm method can effectively improve the image quality after transmission.

V. CONCLUSION

In this paper, we present a tansmission system by ISPIHT compression format with UEP and MFSK/FFH system under PBNJ. We showed how the ISPIHT works, and then points out that two advantages we have. Next compared the ISPIHT, MSPIHT and SPIHT algorithm in image transmission, then we found that in the same compression ratio, ISPIHT has better PSNR value. ISPIHT algorithm is has not only better image quality, the output of important information is also more focused, making the output data stream is more suited to UEP to protect data. In terms of data protection, we use two different error correct capacity of the RS code. Contains important information front-end and other parts of the given coding protection has reached the UEP purpose.

VI. REFERENCE

[1] M. B. Pursley and W. E. Stark, "Performance of Reed-Solomon coded frequency-hop spread-spectrum communications in partial-band inter-ference ,"*IEEE Trans. Commun.*, vol. COM-33, pp. 767-774, Aug. 1985.

[2] C. D. Frank and M. B. Pursly, "Concatenated coding for frequency-hop spread-spectrum with partial-band interference,"*IEEE Trans. Commun.*, vol. 44, pp.377-387, Mar. 1996.

[3] Yu. T. Su, Li-Der Jeng, "Anijam capability analysis of RS-coded slow frequency-hopped systems," *IEEE Trans. Commun.*, vol 48, No. 2. Feb.2000.

[4] Q. Zhang and T. Le-Ngoc, "Turbo product codes for FH-SS with partial-band interference," *IEEE Trans. Commun.*,vol. 1, pp.513-520, July 2002.

[5] Li-Der Jeng and C. H. Su, "Image Restoration for Reed-Solomon Coded SFH/MFSK System with Partial-Band Noise Jamming," in *IEEE International Symposium on Intelligent Signal Processing and Communications Systems*(ISPACS'09), pp. 220-223, Kanazawa, Dec 7-9 2009.

[6] A. Said and W. A. Pearlman, "A new fast, and efficient image codec base on set partitioning in hierarchical trees,"*IEEE Trans. on Circuits and Systems for Video Technology*, vol. 6, no 3, pp. 243-250, June 1996.

[7] J.erome M. Shapiro , "*Smart Compression using the Embedded Zerotree Wavelet (EZW) Algorithm*" *in 1993 IEEE Signals, Systems and Computers, 1993. 1993 Conference Record of The Twenty-Seventh Asilomar Conference on*. pp. 486 - 490 vol.1, 1-3 Nov 1993.

[8] Chao-Ping Huang, Li-Der Jeng and Chi-Yang Wei, " A robust image transmission scheme for FFH/MFSK systems under PBNJ" i*n IEEE 2010 International Symposium on Intelligent Signal Processing and Communication Systems* (ISPACS), pp.1-4,6-8 Dec.2010.