Resynchronization of Modified JPEG Using a Power Allocation Scheme in a Direct Sequence CDMA System

Choon-Sik Yim, Jae-Sung Roh, Eun-Suk Choi, Joong-Hwan Baek, and Sung-Joon Cho

ABSTRACT— *In this paper, we discuss recovery schemes for errors occurring when image data encoded with variable length coding (VLC) is transmitted through additive white Gaussian noise (AWGN) and multiple–access interference in direct sequence code division multiple access (DS/CDMA) systems. VLC such as JPEG is so sensitive to channel errors that severe degradation in decoded images occurs even if only one or two bits have errors. This is due to the loss of synchronization at the image decoder. We propose a resynchronization scheme using a power allocation method in wireless DS/CDMA transmission. Through simulation, we know that the proposed method has a more robust resynchronization capability and higher objective and subjective quality than the conventional method.*

I. INTRODUCTION

In these days, code division multiple access (CDMA) technology has rapidly developed, but mobile communication services using CDMA techniques mainly depend on voice because of the limitation of using wireless transmission media. CDMA users desire multimedia contents, such as wireless data, voice, image, and video communication services, to be provided in the wireless environment, just like the same level of services provided in the environment of an intelligent transport system [1]. However, images require large amounts of data. In order to transmit image data over a wireless channel, an image compression scheme is required for reducing redundancy.

Since most existing compression schemes concentrate only on the compression ratio aspect rather than the transmission aspect, the amount of compressed data is still suboptimal. Additionally, the data is very sensitive to channel errors, and the reconstructed image quality is significantly degraded even if only a few bit errors occur. Even a single bit error can render the remainder of the bit streams useless. Channel coding can alleviate this problem at the expense of a higher data rate. However, if the errors exceed the bounds of the channel code's detection/correction capability, then the resulting errant source data can suffer variable length coding (VLC) decoding errors [2].

In wireless image transmission, resynchronization is very important, so we use the two orthogonal sequences: one for spreading the end of block (EOB) bits for synchronization and the other for data bit streams. While the use of two spreading sequences results in higher multiple access interference and a decrease in the overall capacity of the CDMA system, the correlation characteristic of the pseudorandom noise (PN) code used for EOB bits makes resynchronization accurate. In this paper, we allocate a higher power for EOB bits to distinguish the EOB bits from the data bit streams. However, to make this feature successful, a fast power control in the transmitter is required for the proposed system.

Though some studies [2]-[4] have been conducted on developing resynchronization techniques, they could not be

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applied in practical wireless channel environments. We simulated a wireless CDMA channel for transmitting image data, and this report describes our practical resynchronization method, which is more robust against wireless channel errors than conventional methods.

II. EFFECT OF CHANNEL ERROR IN MODIFIED JPEG

1. Modified JPEG

The JPEG algorithm is performed as follows. First, after processing the discrete cosine transform (DCT) and quantization, the DC coefficients are encoded by differential pulse code modulation. Then the values of the encoded DC and AC coefficients are entropy coded with Huffman tables. Thus, if errors occur in the DC coefficients, the errors propagate through the whole image, and in addition, due to error propagation, the image decoder might desynchronize. To prevent this error propagation, we modify the JPEG standard to have 7 bits fixed length in all DC coefficients. However, AC coefficients are encoded in lengths equal to those of JPEG.

2. Conventional Method to Resynchronize

The JPEG standard has allowed the use of a special “restart marker.” Similarly, [2]-[4] employed restart markers in each row to limit error propagation.

The effects of errors on bit streams are classified as follows:

- Type I error—when the number of decoded blocks is more than that of the original blocks;
- Type II error—when the number of decoded blocks is less than that of the original blocks;
- Type III error—when the error affects only one block;
- Type IV error—when the number of decoded blocks is equal to that of the original blocks despite error propagation.

Type III and IV errors rarely occur and the effect on reconstructed image quality is not serious [2]-[4]. For Type I and II errors, resynchronization is performed in [2]-[4] as follows:

Type I Error

The DCT coefficients detected from erroneous blocks will have small values in the low frequency components. Therefore, by comparing the DCT coefficients of each block with those of the previous row, it is possible to find the erroneous block by choosing the block that has the largest difference in coefficients in the row. After detecting the erroneous block as above [2]-[4], remove the two split blocks and reconstruct a new block. Then every succeeding block has to be shifted left by one block.

Type II Error

As opposed to type I error, the DCT coefficients detected from erroneous blocks will have large values in the high frequency components. As with type I error [2]-[4], choose the block with the largest difference as the erroneous block. Now that the erroneous block is merged into one block, it should first be split into two blocks. Then, every succeeding block should be shifted right by one block.

A resynchronization algorithm like the one above is efficient only when a single block is split into two blocks or two blocks merge into a single block in a certain row. To overcome this limitation, we propose a more robust resynchronization method that does not use the restart marker used in the conventional method.

III. PROPOSED METHOD

In the case of a block-based VLC, if we know the length of each block at the receiver, we can resynchronize easily and prevent error propagation even though many bit errors occur. The proposed method can be applied to a block-based compression scheme to transmit the image over a wireless channel. Thus, we propose to design a transmitter/receiver that can obtain the length of the block using power allocation.

1. Transmitter and Receiver

A special code, 1010, is used to encode the EOB, which is known as the end of each block in the Huffman table. The EOB is the most important code for synchronizing the bit streams. Therefore, we assign to the EOB a higher power than other bit streams. Then we spread and transmit the bit streams using two different spreading sequences: one is used to spread the EOB and the other is used to spread other bit streams. Using the two spreading sequences, we can allocate the minimum power to identify the EOB at the receiver.

The receiver considers the received signal to be the larger of the two signals despread using the two spreading sequences equivalent to the transmitter. Therefore, the receiver can determine that the bit streams are EOB when the spreading sequence for the EOB is used four times in a row. The receiver can then obtain the block length by counting until it receives the bit streams considered as EOB. Finally, the receiver stores the obtained block length and the counter resumes counting from the next received bit. This procedure is repeated until all bit streams are received. However, this procedure has problems in the following situations: 1) when the spreading sequence for the EOB is used to spread non-EOB bits due to a wireless channel error; 2) when the error occurs in the EOB itself.

In order to solve the first problem, the sliding window scheme is adapted, as shown in Fig. 1.

We can decide whether the bit streams are EOB by summing 4 despreading values within a window: because there is little chance that spreading sequences for the EOB are used to spread non-EOB bits four times in a row, the sum of 4 despreading values within a window should have a lower value than a certain level. Therefore, we can also solve the second problem by allocating a higher power for the EOB. In order to obtain the threshold value, which determines the amount of allocated power for the EOB, we consider a situation as shown in Fig. 2.

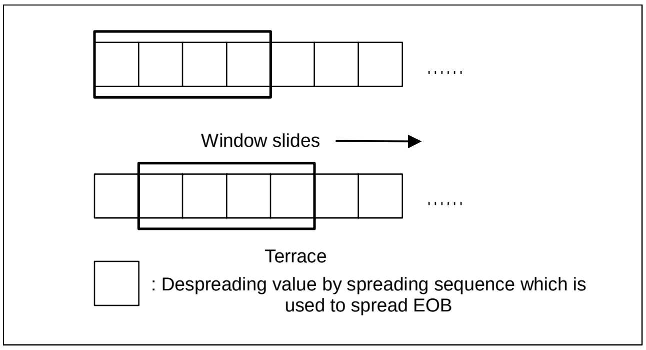

Fig. 1. High power allocation scheme using window.

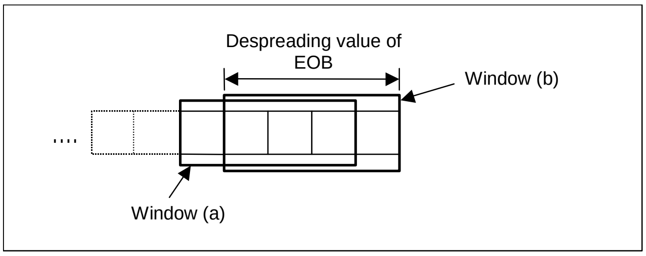

Fig. 2. The criterion of power allocation for the EOB.

It is a much more difficult situation to distinguish non-EOB from EOB. To do this, we increase the power of the EOB by 1 dB until we obtain a threshold which enables us to distinguish the sum of window (a) from that of window (b) at the receiver.

Finally, if we transmit an EOB at a power that distinguishes the sum of window (a) from that of window (b) at the transmitter, then we can set a threshold value which enables us to know the EOB at the receiver. Also, as the receiver already knows that the EOB is coded 1010, the bit streams considered as EOB can be directly decoded to 1010 at the receiver without passing the detector.

In this paper, we consider the reverse link of a DS/CDMA system. At the base station, the receiver can know the channel condition by monitoring the wireless environment. Therefore, using this side information, the BS receiver can set the threshold level. Figure 3 shows the threshold values that make it possible to distinguish the sum of window (a) from that of window (b) at the receiver. In the simulation, we set E_b / N_0 at 10 dB and the length of the spreading sequence at 64.

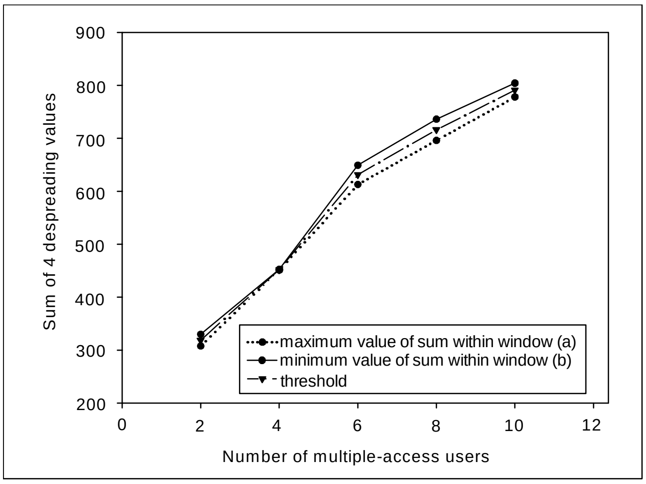

Fig. 3. The selection of threshold values.

2. Error Concealment

Error propagation makes blocks have larger absolute values of AC coefficients than DC coefficients in the DCT-domain when an image is decoded. However, since such blocks do not exist according to the properties of the DCT, we can consider them to be erroneous blocks. Those blocks are checked in the DCT-domain, and flags are set. Error concealment is then performed, which interpolates the checked block referring to 8 neighbor blocks in the DCT-domain. In order to perform error concealment, we first investigate edges using a differential operator and threshold in the pixel-domain [5]. Four possible edge directions, namely, vertical, horizontal, ascendant, and descendant diagonal edges are investigated for each erroneous block. If no edges are found, then the coefficients of the block are estimated by ordering each coefficient of the 8 neighbor blocks and then averaging the 4th and 5th values. Otherwise, if one or more edges are found around the erroneous block, the coefficients of the blocks containing edges are taken into account in estimation as in the following expression:

$$err\_blk(i) = \frac{\sum_{k=1}^{8} w_k ref_k(i)}{\sum_{k=1}^{8} w_k}, \qquad 0 \le i \le 63 \qquad (1)$$

where k is the index of the reference block, i is the coefficient order after zig-zag scanning, and w_k is the weight of the k-th reference block. Accordingly, $ref_k(i)$ is the i-th coefficient of the k-th reference block.

IV. SIMULATION RESULT AND CONCLUSION

Figure 4 shows the peak signal-to-noise ratio according to the number of users when the "Lena" image is transmitted using the conventional method of [2]-[4] and the proposed method. The simulation environment is as follows: $E_b / N_0 =$ 10 dB and the length of spreading sequence is 64. From the reconstructed image, we can see that our proposed method has a more robust resynchronization capability and higher objective and subjective quality than the conventional method. In this letter, we proposed an image transmission system using variable power allocation and two different spreading sequences and then evaluated its performance by designing a DS/CDMA system. In addition, since bit streams of the EOB skips the detector block, channel noise can be avoided at the receiver, and therefore the EOB can be decoded as an error free condition. Our study shows that the proposed system limits the propagation of errors by using a counter which counts the length of each block, and that it provides an improvement of image quality by modifying the JPEG standard and performing efficient error concealment.

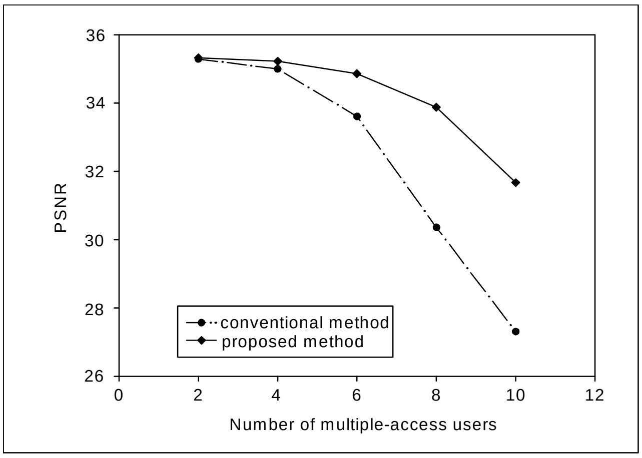

Fig. 4. PSNR with the conventional and proposed methods.

REFERENCES

[1] B.S. Lee, C.S. Yim, D.H. Ahn, and D.K. Oh, "Performance Evaluation of the Physical Layer of the DSRC Operating in 5.8 GHz Frequency Band," *ETRI J.*, vol. 23, no. 3, Sept. 2001, pp. 121-128.

[2] W.M. Lam and A.R. Reibman, "Self-Synchronizing Variable-Length Codes for Image Transmission," *IEEE Proc. ICASSP*92, vol. 3, Mar. 1992, pp. 477-480.

[3] M.E. Petsalis, M.R. Soeymani, and M.N.S. Swamy, "Effects of Errors and Error Recovery in Images Compressed by the JPEG Still Image Compression Standard Algorithm," *IEEE Proc. Canadian Conf. on Electrical and Computer Engineering*, 1994, pp. 396-400.

[4] W.W. Zhu, Y. Wang, and Q.F. Zhu, "Second-Order Derivative-Based Smoothness Measure for Error Concealment in DCT-Based Codecs," *IEEE Trans. on Circuits & Systems for Video Technol.*, vol. 8, no. 6, 1998, pp. 713-718.

[5] M. Ancis and D.D. Giusto, "Reconstruction of Missing Blocks in JPEG Picture Transmission," *IEEE Pacific Rim Conf. on Communications, Computers and Signal Processing*, 1999, pp. 288-291.