ERROR CONTROL FOR LOW BIT RATE CODING TRANSMISSION

Hsiang-Cheh Huang and Hsueh-Ming Hang
Department of Electronics Engineering,
National Chiao Tung University,
Hsinchu, Taiwan 300, ROC

ABSTRACT

Video compression is an indispensable element in multimedia communications systems. We simulate the *H.263* video coder and pass the compressed data through a simulated mobile communication channel. Preliminary results indicate that the error control codes, such as BCH codes, are very useful for protecting the compressed data. In addition, the error correcting capability of the lapped orthogonal transform (LOT) are also investigated.

I. INTRODUCTION

Due to the growing popularity of computer and network, multimedia communications become more and more important. Recently, the interest in very low bit rate video coding has increased considerably with the creation of new services and applications including this element in them [1]. The newly proposed standard, H.263 [2], aims at solving the problem of very low bit rate transmission. We are interested in transmitting low rate video through mobile channels, which have strong noise and distortion.

II. H.263 OVER MOBILE CHANNEL SIMULATION

The compressed data are known to be very sensitive to channel errors. Thus, some protection methods should be applied to the compressed data. In this paper, video sequences are compressed by H.263 algorithm, and the compressed bit streams are sent into a simulated *Rayleigh fading channel* model. Error control codes (BCH codes) are used to protect the compressed bit streams [3]. The receiver first performs BCH decoding, then it performs the H.263 decoding process. The simulation system diagrams are shown in Figs. 1(a) and 1(b). The popular Jakes' model [4] is adopted in our experiments to simulate the mobile fading channel.

Some preliminary simulation results, shown in Fig. 4, have been completed using the Jakes' model and the (511,493) BCH code [3] which is proposed in the Annex H of H.263. It is clear from this figure that the unprotected pictures are severely damaged at SNR = 40dB (Fig. 4(b)) and are totally lost at SNR = 30dB (Fig. 4(d)). The protected pictures show much improved subject quality (Figs. 4(c) and (e)). This is due to the fact that the compressed stream is sensitive to bit errors. A single error could propagate and destroy a long segment of an image. In our simulation we pass the H.263 encoded bit stream to a simulated *Rayleigh fading channel* with preselected background SNR (40 dB or 30dB), multipaths (22 paths), and mobile station velocities (100 km/hr) [5] [6], and then decode the corrupted sequence by the H.263 decoder, as shown in the block diagram of Fig. 1(a). We can reduce the distortion by incorporating the (511,493) BCH code in transmission. The bit error behavior of the simulated mobile channel at various SNR with and without (511,493) BCH code is depicted in Fig. 2.

What we have found so far are:

1. The BCH code has only a slight increase in transmission bit rates. In the case of (511,493) BCH code, the error correcting capability is $t = 2$ and the increase in bit rate is only 3.6%.
2. The channel codes greatly reduce the error propagation problem.

III. LOT VS. DCT CODING OVER THE NOISY CHANNEL

We can also insert the error protecting capability into the source coding schemes by employing a different type of transform coding structure. The *lapped orthogonal transform* (LOT) [7] is a scheme which may have a good potential for this purpose. LOT can be implemented based on DCT with some modifications as in Fig. 3. However, the data produced by LOT contain not only the current block image, but also its neighboring blocks. On the other hand, LOT can still keep the orthonormal properties similar to that of DCT.

Because the coefficients in the LOT domain contain

0-7803-4371-9/97/$10.00

both the information of the current block and the partial information of the adjacent blocks, it is possible that if the data in the current block is lost, the lost picture can still be recovered to some extent with the help of proper concealment schemes [8]. Assuming that there is a channel model which causes the encoded bits to disappear regularly. For example, in our simulation, the 25% lossy channel means that there is one data block loss out of every four blocks in the transform domain. The lost data are set to zero values at the receiver. Here we tested two reconstruction methods.

Assuming that the lost block $\mathbf{b}_{i,j}$, located at position (i,j), has some degree of correlation with its four neighboring blocks. In general, we choose the two weighting factors α and β in the horizontal and vertical directions, respectively. Thus, the reconstructed block in general can be represented by

$$\mathbf{b}_{i,j} = \frac{1}{2}\left(\begin{array}{l} [\alpha \cdot \mathbf{b}_{i-1,j} + (1-\alpha)\cdot \mathbf{b}_{i+1,j}] + \\ [\beta \cdot \mathbf{b}_{i,j-1} + (1-\beta)\cdot \mathbf{b}_{i,j+1}] \end{array} \right) \quad (1)$$

where $\alpha, \beta \in [0,1]$. We simulated the recovered images with different weighting factors which produce different PSNR values. Fig. 5 shows the results of using LOT on the first frame of the test sequence `claire`. From Fig. 5, we know that the PSNR has its maximum value when $\alpha, \beta \in [0.4, 0.7]$. Therefore, if we choose $\alpha = \beta = \frac{1}{2}$ for simplicity, we have the reconstruction method 1.

Reconstruction method 1 is illustrated by Fig. 6. We use the four neighboring blocks (left, right, upper, and lower block) and then take an average of the neighbors to replace the lost data at position (i,j) in the transform domain. That is,

$$\text{lost}_{i,j} = \frac{1}{4}\left(\begin{array}{l} \text{coeff}_{(i-1),j} + \text{coeff}_{(i+1),j} + \\ \text{coeff}_{i,(j-1)} + \text{coeff}_{i,(j+1)} \end{array} \right). \quad (2)$$

In [9] the author suggested that the DC coefficient in the transform domain should be strongly protected in the ATM network environment. Assuming that the DC coefficient can be nearly noise free, the reconstruction method 2 is the combination of this DC protection method and the averaging scheme in reconstruction method 1.

Simulation results on still pictures show that the LOT produces better results objectively and subjectively as indicated in Fig. 7 and Table I. In this simulation, we assume one out of four blocks is lost completely. Because of the overlapping characteristics of LOT, the artifacts on the recovered LOT pictures are less objectionable.

IV. SUMMARY

First of all, we see the advantages of using error control coding in the Rayleigh fading channels. Channel coding introduces some redundancy. In the case of transmitting error-sensitive compressed data, error control codes seem to work rather well.

Secondly, from the simulation results shown in Figs. 7 and Table I, we can see that if no recovery method is used, the contaminated coefficients transformed back by ILOT have significantly higher PSNR values than those transformed back by IDCT. However, when the average-recovery method is applied, the LOT is only 0.05 dB better than DCT for the first frame in sequence `claire`. Another interesting point is that when the DC coefficient is protected, the resultant PSNR values are higher. This is because the DC component contains more than 90% of energy of the picture. Thus, if the DC component can be well protected, the minimum image quality can often be guaranteed.

V. FUTURE WORK

We are now investigating the effect of LOT on motion pictures. Particularly, if the DCT in H.263 is replaced by the LOT, we are interested in knowing its error recovery ability.

VI. REFERENCES

[1] T. Ebrahimi, *et al.*, "New Trends in Very Low Bit Rate Video Coding", *Proc. IEEE*, PROC–73, 877–891, (1995).

[2] ITU–T, "Draft H.263: Line Transmission of Non-telephone Signals," (May 2, 1996).

[3] S. Lin and D. J. Costello, Jr., *Error Control Coding: Fundamentals and Applications*, Prentice-Hall, Eaglewood Cliffs, NJ, (1983).

[4] M. D. Yacoub, *Foundations of Mobile Radio Engineering*, CRC Press, Boca Raton, FL, 1993.

[5] R. Mickos and L. Onural, "Simulation of A DCT Based Very Low Bit Rate Codec for Mobile Video Coding," 7^{th} *Mediterranean Electrotechnical Conf. Proc.*, 203–206, (1994).

[6] P. Cherriman, "Homepage," `http://rice.ecs.soton.ac.uk/peter/robust-h263/`, (1996).

[7] H. S. Malvar and D. H. Staelin, "The LOT: Transform Coding without Blocking Effects," *IEEE Trans. Acoust., Speech, Signal Processing*, ASSP–37, No.4, 553–559, (1989).

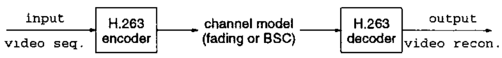
[8] S. S. Hemami, "Reconstruction–Optimized Lapped Orthogonal Transforms for Robust Image Transmission," *IEEE Trans. Circuits Syst. Video Technol.*, 6, 168–181, (1996).

[9] P. Haskell and D. Masserschmitt, "Reconstruction Lost Video Data in A Lapped Orthogonal Transform Based Coder," *1990 International Conference on Acoustics, Speech and Signal Processing*, vol.4, 1985–1988, (1990).

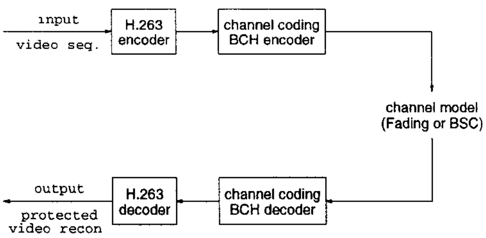
TABLE I

A comparison of encoding the first frame in sequence claire with 25% data loss channel for the two reconstruction methods.

state	recovery method	DCT PSNR (dB)	LOT PSNR (dB)
claire with 25% data loss	no recovery	12.56	13.47
	method #1	30.51	30.60
	method #2	32.45	32.86



(a)



(b)

Fig. 1. (a) H.263 coding over noisy channels. (b) H.263 coding with BCH codes.

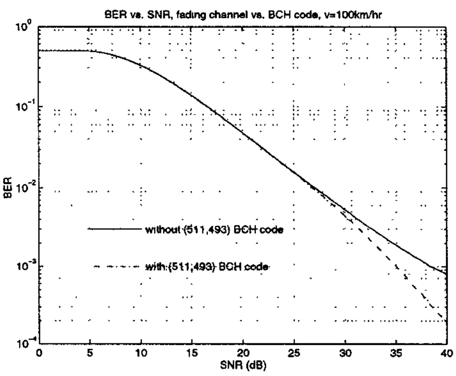


Fig. 2. Jakes' model simulation. Mobile velocity = 100 km/hr.

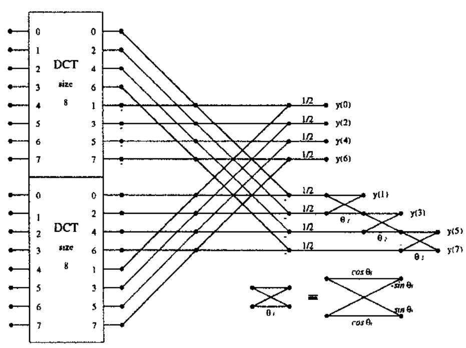
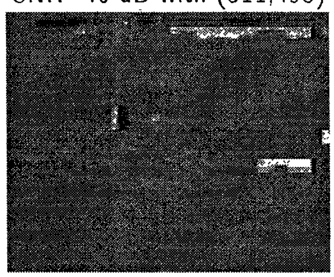


Fig. 3. Structure of the fast LOT algorithm, the number of output coefficients $M = 8$, and the number of input pixels $L = 16$.

(a) original, distortionless

(b) distorted, channel SNR=40 dB

(c) channel SNR=40 dB with (511,493) BCH code



(d) distorted, channel SNR=30 dB

(e) channel SNR=30 dB with (511,493) BCH code

Fig. 4. (a) The original of claire. (b) Encoded bit streams passing through the 40-dB *Rayleigh fading channel* without error control codes. (c) Encoded bit streams passing through the 40-dB *Rayleigh fading channel* with (511,493) BCH code. (d) Same as (b), except that the SNR changes to 30 dB. (e) Same as (c), except that the SNR changes to 30 dB.

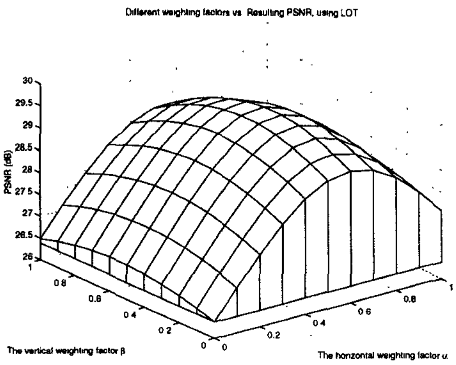


Fig. 5. The weighting factors α, β vs. reconstructed PSNR for LOT.

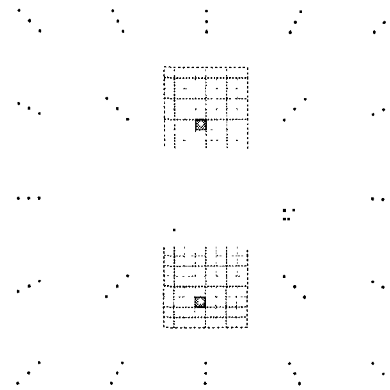
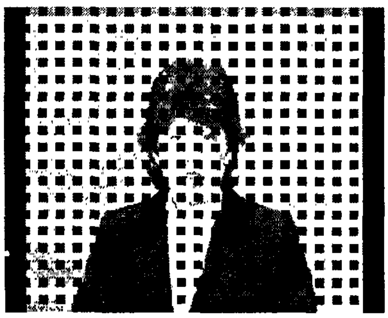
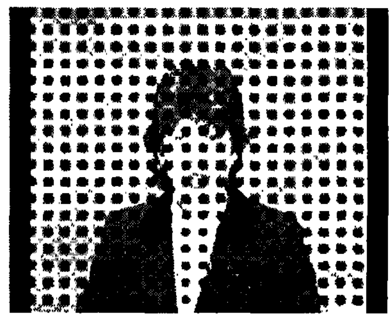


Fig. 6. Reconstruction method 1. The shaded block means the 37^{th} AC coefficient.

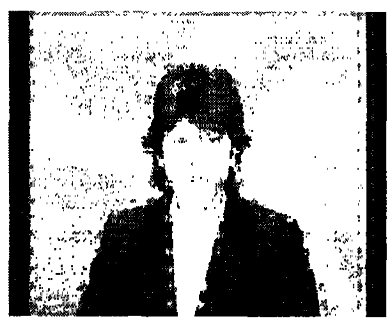


(a) 25% data loss and IDCT recovered



(b) 25% data loss and ILOT recovered

(c) Recovered by DCT and average-recovery



(d) Recovered by LOT and average-recovery

(e) Recovered by those in (c) and DC-protected

(f) Recovered by those in (d) and DC-protected

Fig. 7. A comparison of the first frame in the sequence claire processed by DCT and LOT with two recovery methods. Numerical results are given in Table I.