Soft Decision Scheme for Multiple Descriptions Coding over Rician Fading Channels

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ABSTRACT

This paper presents a new MDC scheme for robust wireless data communications. The soft detection making of the MDC scheme utilises the statistical received data error obtained from channel decoding. The coded bit stream in the system is protected using either the Reed Solomon (RS) or Low Density Parity Check Codes (LDPC) channel coding scheme. Simulation results show that this system has some significant performance improvements over the single description or single channel transmission systems in terms of symbol error rate and peak signal-to-noise ratio PSNR. The system with RS codes is 2 to 5 dB better than single description. The system with LDPC channel codes is 6 to10 dB better than the single description.

Keywords: Multiple Descriptions Coding, Rician fading channel and Image transmission.

1. INTRODUCTION

In recent years, many researchers have involved in the development of Multiple Descriptions Coding (MDC) techniques which improves the robustness of wireless data transmission as presented in [1-9]. In MDC technique, retransmission of the lost information is not required since the receive data are sufficient for quality reconstruction. Retransmission often incurs unacceptable delay. This makes MDC particularly appealing for real-time interactive multimedia applications such as multimedia communication for mobile and video conferencing.

There have been lot of research activities done for applications in multimedia communication. For example, in [1-2] present the works done for image coding, in [3-4] present the works done for video coding, and in [5-7] present the works done for audio as well as speech coding. Other related works to MDC technique include the use of quantization such as MD scalar quantizers (MDSQ) as presented in [8] and the work that involves transformation technique, such as MD Transform Coding (MDTC) as presented in [9].

In this paper, a new MDC coding scheme is introduced where the soft decision making of the reconstructed image is based on the statistical data error channel decoding. An image transmission system that consists of the new MDC scheme and channel coding scheme is simulated over wireless channels. The coded bit stream is protected either using the RS or LDPC as well as the hybrid of RS and LDPC codes. Results for the system with RS codes are 2 to 5 dB better than single description. Results for the system with LDPC codes are 6 to 10 dB better than the single description.

a. Proposed MDC scheme

The proposed image transmission system that consists of the new MDC scheme and channel coding is illustrated in Fig. 1.

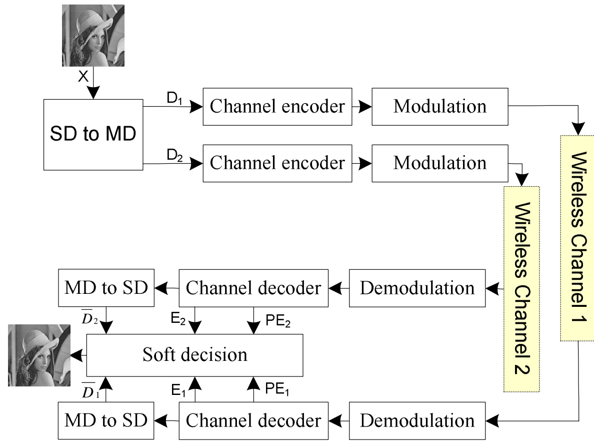

FIGURE 1: A Multiple Description System

An image is first divided into several packets, where the size of each packet is determined by size of the image row. At this stage the data are considered single description (SD) data. Then, each element $X(i, j)$ in SD packet is converted to a pair of elements ($D_1(i, j)$, $D_2(i, j)$). At this stage the data are considered as multiple descriptions (MD) data. The conversion formula used is as the following;

$$D_1(i, j) = \frac{X(i, j)}{2} + 1 \quad (1)$$

$$D_2(i, j) = \frac{X(i, j) + 1}{2} \quad (2)$$

This can be considered as combining the neighbouring data (pixels) of the original data as shown in Table 1.

Table 1: Single to Multiple Descriptions

<table>
<tr><td>$X(i, j)$</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>…</td></tr>
<tr><td>$D_1(i, j)$</td><td>1</td><td colspan="2">2</td><td colspan="2">3</td><td colspan="2">4</td><td colspan="2">5</td><td>6</td><td>…</td></tr>
<tr><td>$D_2(i, j)$</td><td colspan="2">1</td><td colspan="2">2</td><td colspan="2">3</td><td colspan="2">4</td><td colspan="2">5</td><td>…</td></tr>
</table>

The MD data sequences are then coded using either the RS codes or using the LDPC codes. Both schemes use the same code rate of 1/3. Then, the encoded data are transmitted over wireless channels after BPSK modulation process.

At the receiver, the data are first demodulated by the BPSK demodulator. Then, the data are decoded using either the RS or LDPC decoder. The channel decoder has three outputs i.e. the decoded MD data, sum of error in the packet (channel 1 error $E_1(i)$ or channel 2 error $E_2(i)$), and symbol pairs $R_k(i, j)$. Then the MD data are converted to a SD data. The next process is the conversion of MD to SD data. This is the inverse of SD to MD process given by equation 3 and 4.

$$\overline{D}_1(i, j) = 2 * (R_1(i, j) - 1) \quad (3)$$

$$\overline{D}_2(i, j) = 2 * R_1(i, j) - 1 \quad (4)$$

$$\overline{D}_0(i,:) = \overline{D}_1(i,:) \qquad if \quad E_1(i) = 0 \quad (5)$$

$$\overline{D}_0(i,:) = \overline{D}_2(i,:) \qquad if \quad E_2(i) = 0 \quad (6)$$

The final process is the soft decision algorithm, where it takes the best data out of the two channels. There are three possible inputs to this process;

The best packet will be received from channel 1, if no error occurs during transmission of the whole packet as stated by equation 5.

The best packet will be received from channel 2, if no error occurs during transmission of the whole packet as stated by equation 6.

If there are errors in each channel, the following steps are taken;

a. If $E_1(i) > E_2(i)$: Choose packet from channel 2.
b. If $E_1(i) < E_2(i)$: Choose packet from channel 1.
c. If $E_1(i) = E_2(i)$: Compare each component from both packets, and the check the pixel error PE_1 and PE_2 values. Choose the component where the PE_i of zero value.

The entire process is summarised by the flow chart shown in Fig. 2.

Simulation Results

This section presents the simulation results of the system using two different channel coding schemes. The first scheme uses RS channel coding and the transmission is carried out over AWGN channel. The channel condition is varied by changing the signal to noise ration (SNR) for each transmission. Then, a different channel i.e. the Rician fading channel is used. The second scheme uses LDPC codes as channel coding. The standard image "Lena" is used as the test image. The performance is measured based on the Peak Signal to Noise Ration (PSNR) that serves as the quantitative measure of the quality for the reconstructed images.

	SNR(dB) / PSNR(dB)	1	4	7	10
Use RS channel codes	Channel 1	10.37	16.31	34.08	∞
	Channel 2	10.56	16.87	31.59	∞
	Combine between 1&2	10.56	18.81	41.56	∞
Use LDPC channel codes	Channel 1	∞	∞	∞	∞
	Channel 2	∞	∞	∞	∞
	Combine between 1&2	∞	∞	∞	∞

FIGURE 2: Performance in AWGN channel

Table 2 shows the results obtained for image transmission system over AWGN channel. The system consists of the new MDC algorithm and two channel coding schemes. The PSNR performance of the reconstructed image is obtained for channel SNR from 1 dB to 10dB. This results show that the system with LDPC performs better than RS codes at SNR lower than 10 dB.

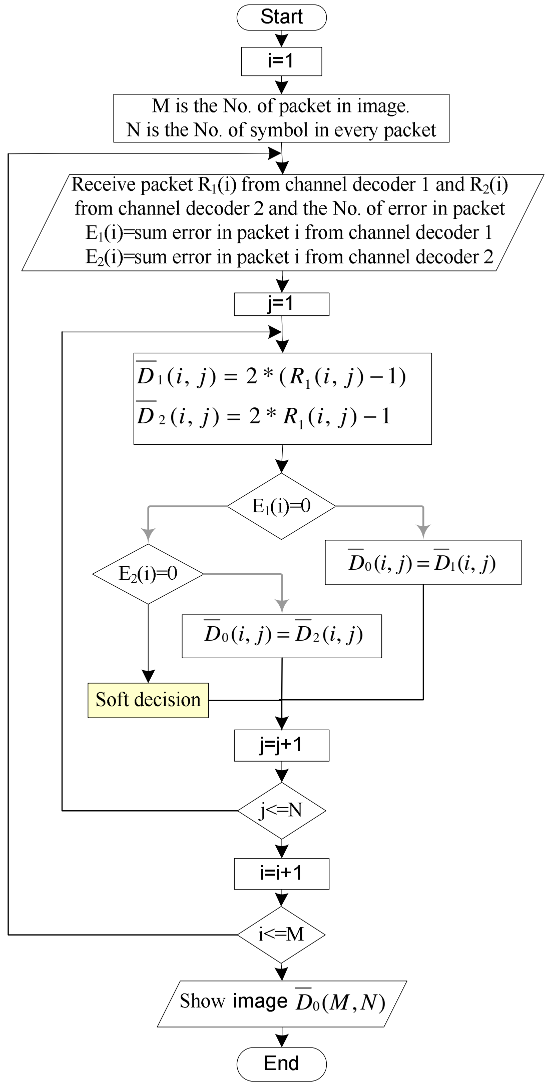

FIGURE 3: flow chart of MD to SD

Fig. 3 shows the results obtained for image transmission system over Rician fading channel. In this simulation, a mobile system with the source rate of 100 kbps and carrier frequency of 900 MHz are assumed. The mobile speed of 120 km/h is used that gives the Maximum Doppler shift as 100 Hz. The AWGN environment is assumed to be with every path in the Rician fading channel. In the simulation, the frequency-selective "multiple paths" Rician channel uses the K-factor equal 10 (K-factor defined as the ratio of signal power for line of sight (LOS) over the scattered, reflected power).
This results show the performance of image transmission system with LDPC codes is better than RS codes. The performance of MD system always outperforms the SD system. For example, looking at 8 dB channel SNR in Fig. 3, for the systems with RS codes, there is almost 2 dB gain obtained by comparing the dotted lines. Similarly, for the systems with LDPC codes, there is almost 5 dB gain obtained by comparing the continuous lines.. The better performance of the system that uses LDPC codes is due to its excellent error correction capability as compared to RS codes over the Rician fading channel.

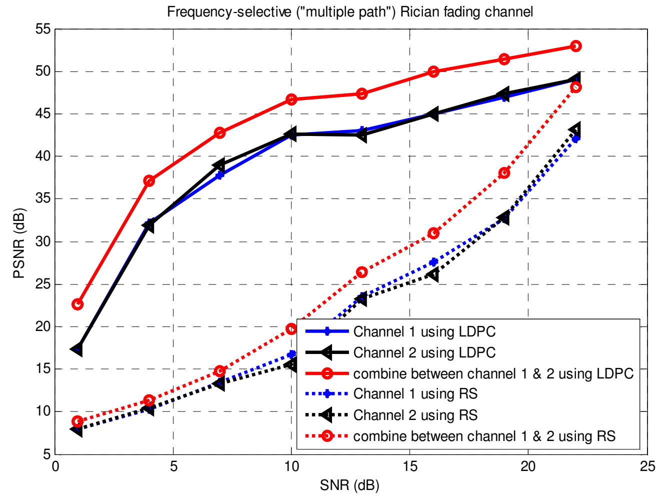

FIGURE 4: PSNR (dB) via frequency-selective “multiple path” Rician channel

1. Conclusions

In this paper the proposed MDC scheme for image transmission system together with two FEC schemes are analysed. The technique has significantly improves the performance of image transmission system in wireless channels. The proposed MDC scheme is an alternative technique for image transmission in wireless channel where methods that use error control schemes such as ARQ are not suitable due to the introduction of delay.

The MDC scheme increases robustness of data transmission. If a receiver gets only one description (other descriptions is lost), it can still reconstruct image with lower but acceptable quality. Simulation results have shown that the image transmission system with LDPC codes performs better than RS codes for both simulation via AWGN and Rician fading channels.

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References

1. V. A. Vaishampayan, “Application of multiple description codes to image and video transmission over lossy networks," Proc. 7th Int. Workshop Packet Video, Brisbane, Australia, pp. 55-60, 18-19/3/1996.

2. Y. Wang, M. T. Orchard and A. R. Reibman, “Optimal pairwise correlating transforms for multiple description coding", Proc. Int. Conf. Image Process, vol. 1, pp. 679-683, Chicago, IL, Oct. 1998.

3. Y. Wang, A. R. Reibman, and S. Lin, “Multiple description coding for video delivery,” Proceedings of the IEEE, vol. 93, no. 1, pp. 57-70, Jan.2005.

4. D. Comas, R. Singh and A. Ortega, “Rate-distortion optimization in a robust video transmission based on unbalanced multiple description coding," IEEE Workshop Multimedia Signal Process., MMSP01, Cannes, France, Oct. 2001.

5. G. Schuller, J. Kova·cevic, F. Masson, and V. K. Goyal, “Robust low-delay audio coding using multiple descriptions," IEEE Trans. Speech and Audio Process., vol. 13, pp. 1014-1024, Sept. 2005.

6. M. Kwong, R. Lefebvre and S. Cherkaoui, “Multiple description coding for audio transmission using conjugate vector quantization," Proc. 122th AES Convention, Vienna, Austria, May 2007.

7. J. Balam and J. D. Gibson, “Multiple descriptions and path diversity using the AMR-WB speech codec for voice communication over MANETs," Proc. IWCMC, Vancouver, Jul. 2006.

8.V. Vaishampayan, “Design of multiple description scalar quantizers,”1EEE Trans. on Info. Theory, vol. 39, no. 3, pp. 821-834, May 1993.

9. Y. Wang, M. T. Orchard, and A. Reibman. “Multiple description image coding for noisy channels by pairing transform coefficients”, Proceedings of the 1st Workshop IEEE MMSP. Princeton, NJ, 1997.