A Robust Wavelet Based Watermarking System for Color Video

Mohsen Ashourian, Hooshang Kazemi
Department of Electrical Engineering, Majlesi Branch, Islamic Azad University, Isfahan, Iran.
Email: mohsena@ieee.org, drkazemi@msn.com

Received: December 2010 Revised: April 2011 Accepted: July 2011

ABSTRACT:
In this paper, we propose a wavelet based watermarking system. The system uses wavelet transform for red, green and blues channel independently. We use space-time coding for encoding the watermark message before data embedding. The bit-error-rate of the recovered message is calculated. The embedding factor is selected in such a way that the host video maintains the same quality with/without using space-time coding. The developed system is further examined, when host video faces compression and noise addition. The result shows the effectiveness of the proposed watermarking system, especially when space-time coding is used.

KEYWORDS: Data embedding, Watermarking, Space-time code.

1. INTRODUCTION

A watermarking system consists of a watermark embedding and a watermark detector, which are analogous to a transmitter and receiver in a communication system. The most common model then views the original work as the communication channel and the watermark as the modulated signal that conveys the message [10]-[11]. The fundamental method to increase reliability of a communication channel was applying error-correcting codes (ECC). The simplest type of is signal repetition [10]-[11]. Signal repetition could be very effective for watermark attacks similar to channel fading like cropping part of image. However, signal repetition needs a lot of bandwidth because repetition would double the necessary bandwidth. Since the number of bits could be embedded into an image is usually very limited, increasing transmission bandwidth would severely limit the transmission capacity. Therefore, we proposed a new method in this paper. That is, to use space-time coding [1] as a form of increasing diversity in image watermarking.

One general way to improve reliability in an unknown, non-stationary environment is to employ diversity [8]. This approach involves transmitting the same information through multiple sub-channels of a hostile communications environment to better guarantee information reception. Examples of diversity in wireless communications include antenna and frequency redundancy. For watermarking, the diversity is introduced by repeatedly embedding the watermark through the host signal [8]. The sacrifice in employing diversity is the bit rate expense because the same information is sent through M orthogonal resources. However, for many watermarking applications, the payload is small.

There are two issues that should be addressed in designing such a kind of system. The first is how to combine the different portions of the encoded watermark to maximize the overall performance, and the second is in what domain, we should introduce coefficient diversity to maximize reliability. In this paper, we choose data embedding in the wavelet domain and in two different subbands. We expect that high resilience of space-time coding of the watermark can help the data embedding scheme to survive various attacks.

In the following sections, at first we review the basic concepts of space-time coding in Section 2. In Section3, the data embedding and extraction are explained. Section 4 provides the results, and finally Section 5 concluded the paper.

2. SPACE-TIME CODING

Space time coding involves the transmission of multiple redundant copies of data to compensate for fading and thermal noise in the hope that some of them may arrive at the receiver in a better state than others [6]. Alamouti invented the simplest of all the STBCs in 1998. The only one standard STBC can achieve full-rate [1]. Fig. 1 shows a block diagram of space-timje coder and receiver. It was designed for a two-transmit antenna system. It takes two time-slots to transmit two symbols. Using the optimal decoding scheme, the bit-error rate (BER) of this STBC is equivalent to $2n_R$-branch maximal ratio combining [6]. This is a result of the perfect orthogonality between the symbols after receive processing — there are two copies of each symbol transmitted, and n_R copies received.

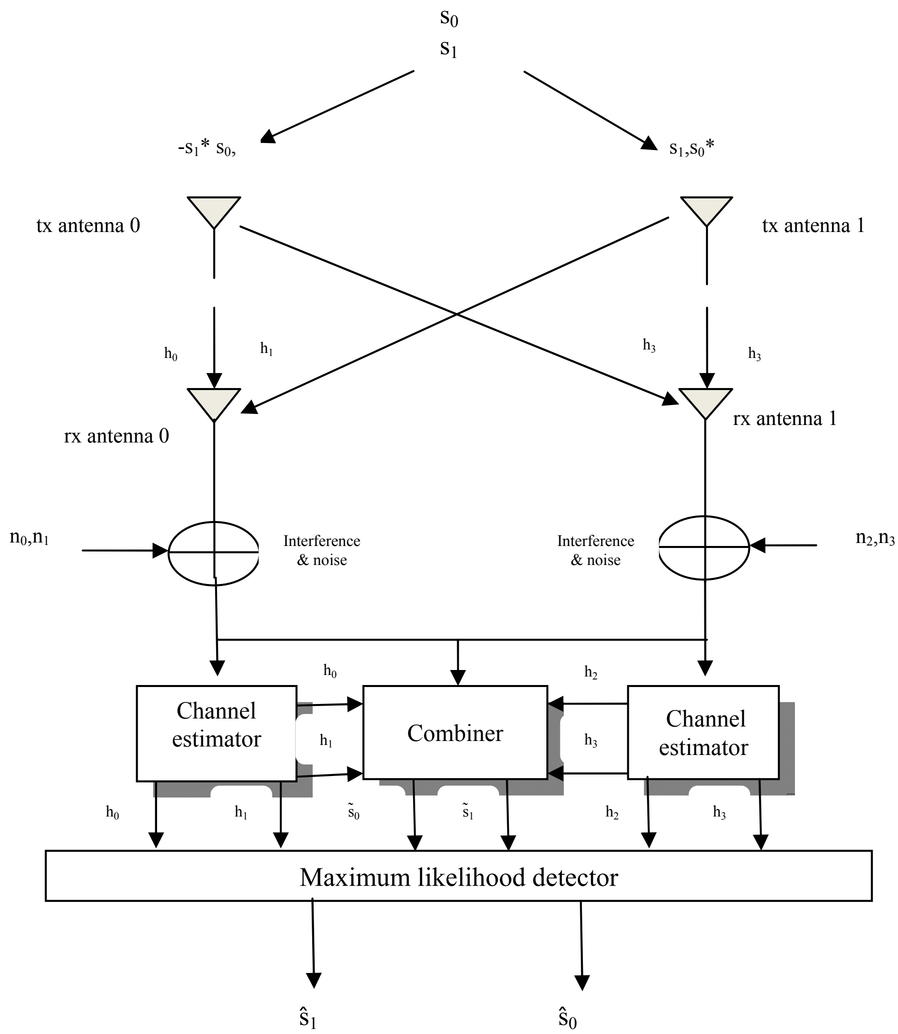

Fig. 1. Space-Time Coding System [1]

3. DATA EMBEDDING AND EXTRACTION

Different digital watermark algorithms have been proposed. These algorithms are mostly transformed domain techniques for still images and for video [5],[7],[9]. We follow the proposed watermark embedding technique in [5] in this paper. Furthermore,, it should be noted that space-time coding could be used for any types of watermarking system.

The system has four steps: 1) Two-Level Discrete Wavelet Transform (DWT) of each color, 2)pseudo-random key generation, 3) watermark insertion, 4) Inverse Discrete Wavelet Transform (IDWT). The block diagram of embedding algorithm is shown in Fig. 2. Each color of the watermarked video frame has transformed to wavelet domain and early generated pseudo-random key image taken into the correlation test. As depicted in Fig. 3, each highest-level subbands in 2-level DWT has four related pixels coming from lower subbands. They gather in 2x2 sub-matrices. So we generate a 2x2 pseudo-random key matrix for each watermark pixel. Let’s say we have the video signal with 352*288 pixel size (QCIF format), which result to a matrix sized 176x144 in HL1 subband. So, our key image will be 176x144 and watermark image size with 88x72, which is a quarter size of the key image. The subband and pixel relation of an image is shown in Fig. 3.

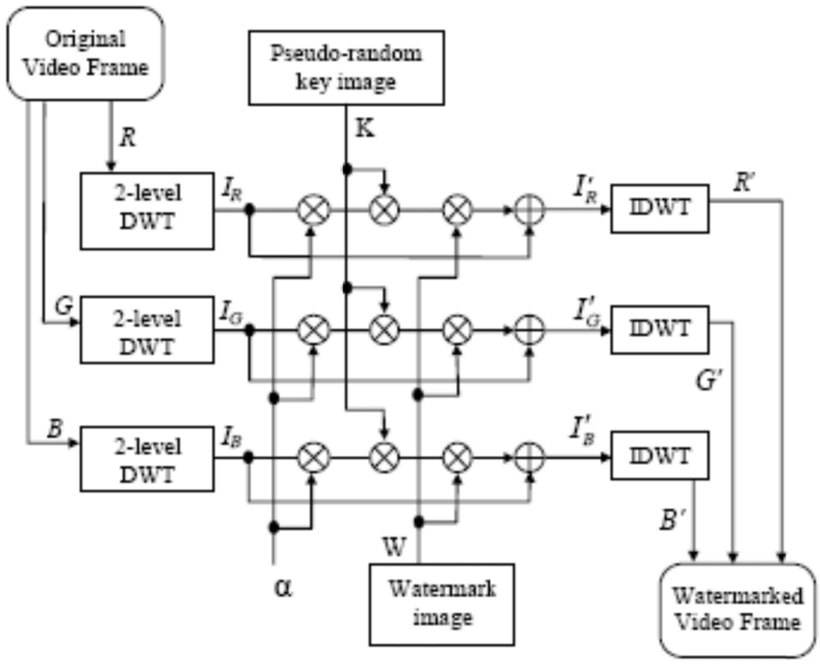

Fig. 2. Data Embedding in the wavelet domain [5]

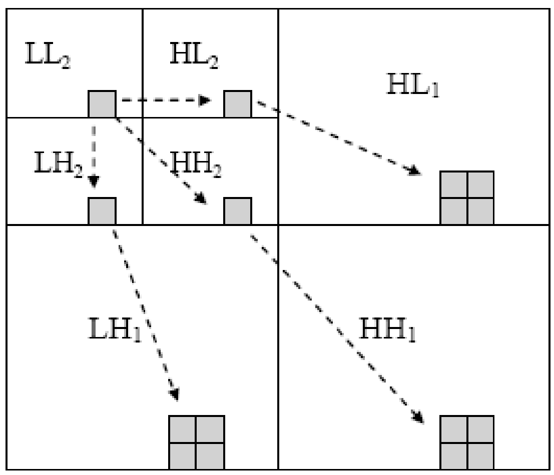

Fig. 3. Host Video Frame Wavelet Decomposition

The generated 2x2 pseudo-random matrix consists of "+1" and "-1" values whose mean value is not 0 or 1. For example, mean value of (1, 1, 1, -1) is 0.5. This prevents from division by zero problems when calculating correlations in watermark extraction. Similar system could be used for data extraction as depicted in Fig. 4.

4. EXPERIMENTAL RESULTS AND ANALYSIS

We examine the watermarking system performance in two cases. Fig. 5 shows the basic system, where the watermark data are embedded directly in the video frames in the wavelet domain. Fig. 6 shows the second system where we use space-time coding for the data before embedding. Since the amount of embedded data is increased two times after data embedding, we set the embedding factor in two cases, with space-time coding and without space-time coding, in such a way that the quality of host video based on its peak signal to noise ratio (PSNR) was nearly equal. We report the bit error rate of recovered data.

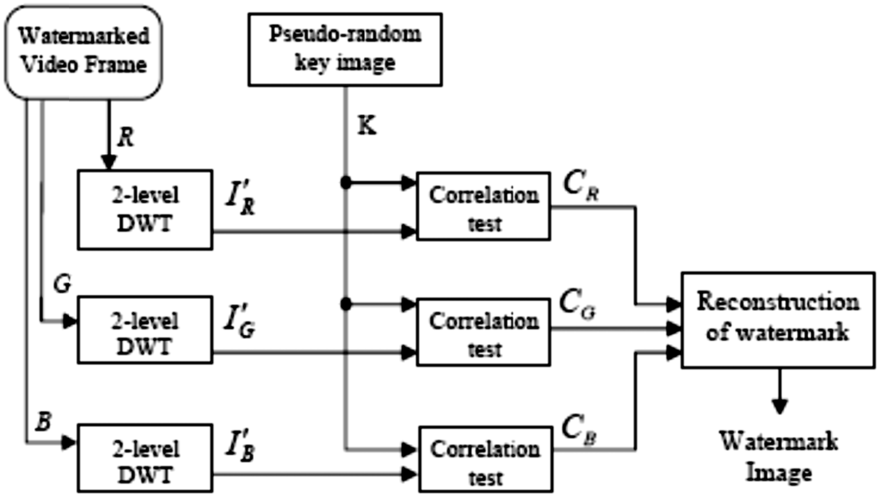

Fig. 4. Data Extraction in the wavelet domain [5]

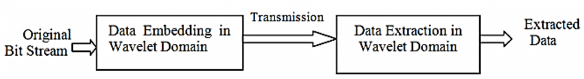

Fig. 5. Original Data Embedding System

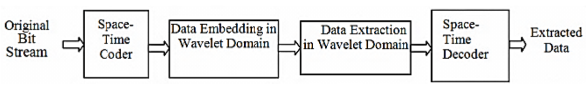

Fig. 6. Modified Data Embedding System with addition of Space-Time Coder

We examine the system performance for three different video sequence depicted in Fig. 7.

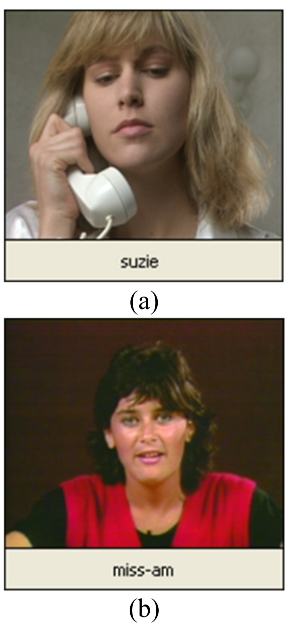

Fig. 7. (a) Suzi, (b)Miss America

Resistance to Compression: The MPEG-2 lossy compression algorithm with used for the video signal and they are encoded at 64Kbps. The bit error rate of reconstructed video after compression is reported in Table 1.

Table 1.. The effect of host video compression on BER of recovered message

	Miss America	Suzie	Salesman
	BER (%)	BER(%)	BER(%)
Basic System	9.9747	3.5985	4.5785
Modified System Using Space-Time Coder	8.5342	2.4345	2.9442

Robustness to Gaussian Noise: We add a Gaussian noise with a different variance to the normalized host video after embedding the watermark. Fig. 8 and Fig. 10 show the variation of BER for additive noise with different variances for the three video sequences. From these figures, we can conclude that for certain range of noise, our strategy improves data embedding to addition of noise.

5. CONCLUSIONS

We have presented a pre-processing method for video watermarking. The watermark data are encoded using a space-time coder, and the two generated bit-streams are embedded in different frequency subbands in the wavelet transform domain. Result show that addition of space-time coder can improve watermarking scheme robustness to various attacks.

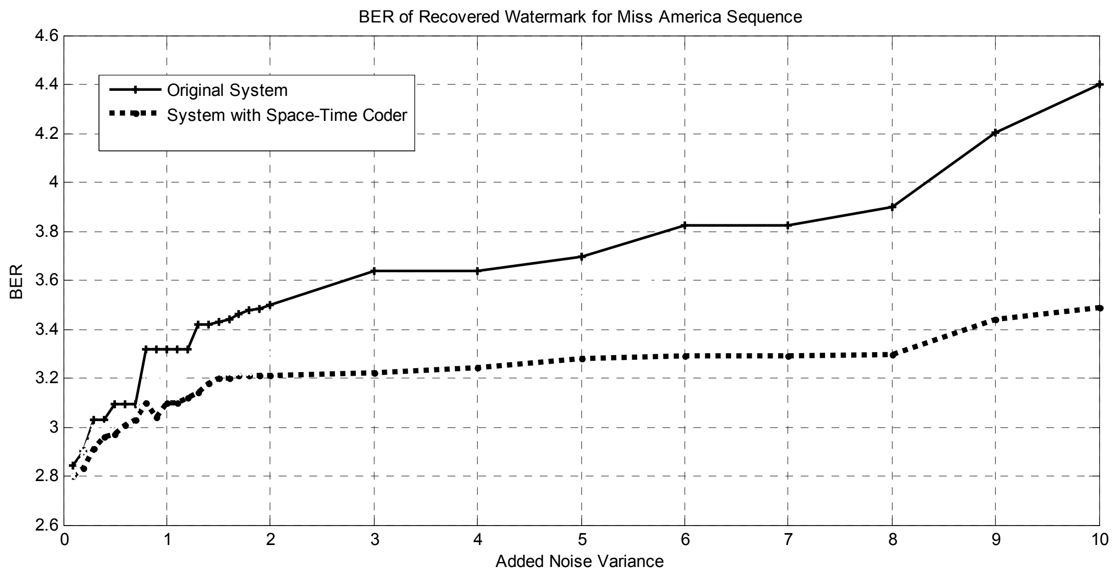

Fig. 8. BER of recovered watermark for Miss. America Sequence

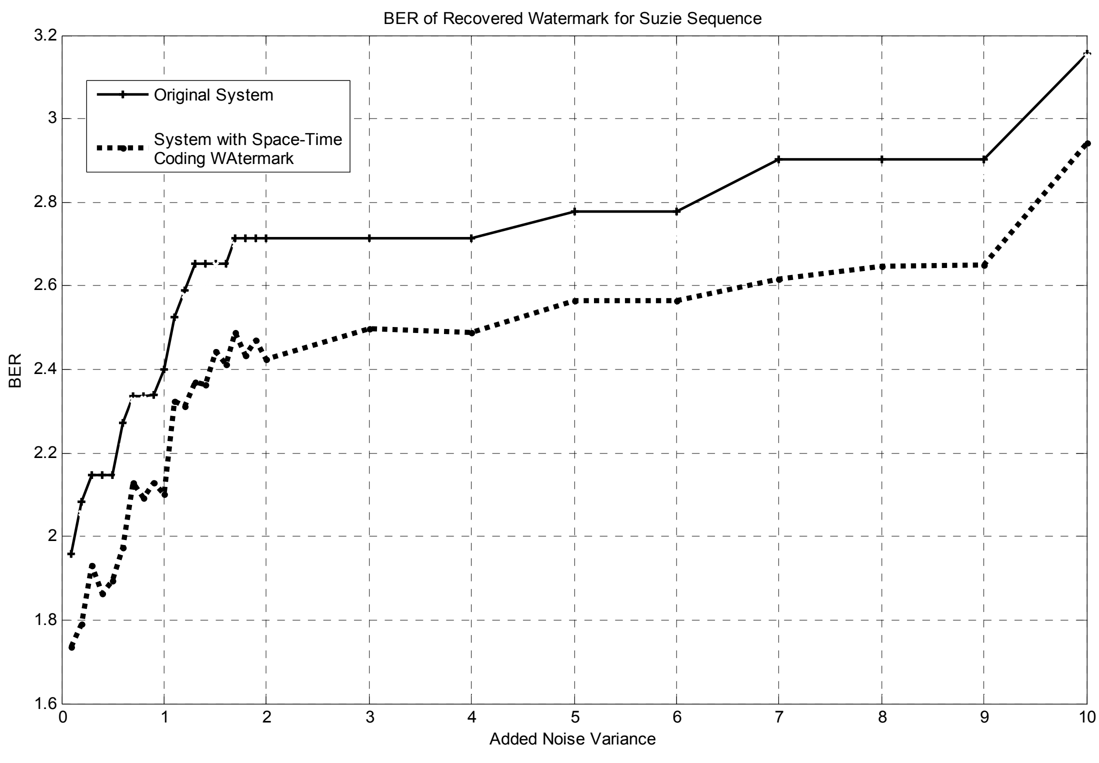

Fig. 9. BER of recovered watermark for Suzie Sequence

REFERENCES

[1] S.Alamouti, **"A simple transmitter diversity scheme for wireless communication"** *IEEE Journal of Selected Areas in Communication*, Vol 17, 1998.

[2] M. Barni, F. Bartolini, A. Piva, **"Multichannel watermarking of color images, "** *IEEE Transactions on Circuits and Systems for Video Technology*, Vol. 12, Issue 3, 142 – 156. 2002.

[3] Chih-Chin Lai, Cheng-Chih Tsai, **"Digital Image Watermarking Using Discrete Wavelet Transform and Singular Value Decomposition, "** *IEEE Transactions on Instrumentation and Measurement,* Nov. 2010, Vol. 59, Issue:11, pp. 3060 – 3063.

[4] J. Cox, M. L. Miller, T. Leighton, A. L. Mckellips, **“Watermarking as communications with side information,”** *Proc. IEEE*. Vol. 87, pp. 1127-1141, 1999.

[5] C. Chouse, Y. Tokur, **“A Wavelet-Based Video Watermarking,”** *ELECO2005,* Vol. 2, pages 180-184, Bursa, Turkey, December 2005.

[6] D. Gesbert, M. Shafi, Da-shan Shiu, P.J. Smith, A. Naguib, **“From theory to practice: an overview of MIMO space-time coded wireless systems,”** *IEEE Journal on Selected Areas in Communications,* April 2003, Vol. 21 Issue:3, pp: 281 – 302. 2003.

[7] Hui-Yu Huang, Cheng-Han Yang, Wen-Hsing Hsu, **“A video watermarking algorithm based on pseudo 3D DCT, ”** *IEEE Symposium on Computational Intelligence for Image Processing*, 2009.PP. 76 – 81. 2009.

[8] D. Kundur, **“Watermarking with diversity: insights and implications, ”** *IEEE Multimedia,* Vol. 8, pp. 46-52. 2001.

[9] M. Kutter, S. Winkler, **“A Vision-Based Masking Model for Spread-Spectrum Image Watermarking”** *IEEE Transactions on Image Processing,* Vol. 11, No. 1, pp.16-25. 2002.

[10] P. Moulin, R. Koetter, **“Data-hiding codes, Proceedings of the IEEE,”** Vol. 93, Issue 12, December. pp. :2083 – 2126. 2005.

[11] P. Moulin, J. A. O'Sullivan, **“Information-Theoretic Analysis of Information Hiding,”** Sep. 2002. *IEEE Trans. on Information Theory*, Vol. 49, No. 3, pp. 563-593, March 2003.

[12] R. O. Preda, D. N. Vizireanu, **“Robust wavelet-based video watermarking scheme for copyright protection using the human visual system, ”** *Journal of Electronic Imaging*, Vol. 20, Issue 1, 2011.