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Digital Watermarking using Cdma Technology

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ABSTRACT

A multiple watermarking algorithm based on the CDMA spread spectrum technique is presented. Multiple copyright Identifiers are convolutional encoded and block interleaved, and the orthogonal Gold sequences are used to spread spectrum of the copyright messages. The CDMA encoded copyright messages are embedded into the original image with the help of discrete wavelet transformation.

1. INTRODUCTION

Digital watermarking is defined as a process of embedding data (watermark) into an image to protect the owner's right to that data.

Along with the explosive growth of the Internet, digital media is very easily accessible by unauthorised persons. This gives birth to the relatively new research field of "digital watermarking" to protect ones intellectual property rights. Now a day various methods are present for digital watermarking like DCT, FFT, LSB, DWT but more secure and robust method is digital watermarking using CDMA technology.

The CDMA is an application of spread spectrum technique. In the CDMA system, multiple users share the same frequency band, at the same time. Unique channels are created and each user directly modulates their information by a unique, high bit rate code sequence that is essentially uncorrelated with that assigned to any other user. The number of users on

the system at the same time is a function of the number of unique code sequences assigned, and the ratio of the code sequence bit rate to information bit rate. The properties of CDMA just satisfy the requirement of multilevel watermarking algorithms. The orthogonal Gold sequences are used to spread spectrum of the copyright messages. The CDMA encoded copyright messages are embedded into the wavelet sub-bands except the wavelet HHl sub-band. The embedded amplitude is decided by Watson's perceptual model of wavelet transform domain, and the embedded position in the selected wavelet sub-bands is decided randomly by a PN sequence.

In this paper, a technique that embeds a binary image as a watermark at selected DWT coefficients by the use of a private key is proposed. This is achieved by spreading the binary image bits into the elements of a matrix row by using CDMA techniques. The depth of watermarking is adjusted to give an image of acceptable quality. A correlation process is used to detect and recover the watermark.

2. CODE DIVISION MULTIPLE ACCESS

The approach used in code division multiple access (CDMA) does not attempt to allocate separate frequency or time resources to each user. Instead it allocates all resources to all simultaneous users, controlling the power transmitted by each to the minimum required to maintain a given signal to noise ratio for the required level of performance. Each user employs a noise-like wideband signal occupying the entire frequency allocation for as long as it is needed. In this way, each user contributes to the background noise affecting all the users, but to the least extent possible. This additional interference limits capacity and quality, but because time and bandwidth resource allocations are unrestricted, the resulting capacity is significantly greater than for conventional systems. Capacity is defined as the total number of simultaneous users the system can support and quality is defined as the perceived condition of a radio link assigned to a particular user. This perceived link quality is directly related to the probability of bit error, or bit error ratio (BER). The actual capacity of a CDMA cell depends on many different factors, such as receiver demodulation, power control accuracy and actual interference power introduced by other users in the same cell and in neighbouring cells. A coarse estimate of the reverse link capacity achieved by such a spread spectrum system is obtained by the following argument. Suppose each user employs a wide-band Gaussian noise carrier. For our purposes, suppose this waveform is stored at both transmitter and receiver, and that the modulation and demodulation are simply multiplication operations at baseband, synchronized between locations. Suppose further that each user's transmitted power is controlled so that all signals are received at the base station at equal power levels.

3. WATERMARK EMBEDDING

Let $I(m,n)$; $1 \leq m \leq M$, $1 \leq n \leq N$ be the MxN 8-bit grayscale cover image which is to be watermarked and $B(p,q)$ $1 \leq p \leq P$; $1 \leq q \leq Q$, be a PxQ binary image which is to be used as the watermark. In our investigations we have used M=N=256 and P=Q=16. The embedding of the watermark into a cover image is performed in the following steps:

3.1. Pre-Processing the Cover Image

Using the 1-level Haar DWT, the cover image is decomposed into four quadrants as illustrated in Fig. 1. The watermark is to be embedded into the H1 and V1 quadrants which are (M/2 x M/2) or 128x128 in size. This is done by segmenting the DWT coefficients in H1 and V1 into non-overlapping blocks of size axa, where a<<(N/2). For a=4, then the quadrant H1 will have a total of 1024 blocks of 4x4 DWT coefficients. The quadrant V1 will also have a similar number of 4x4 blocks.

3.2. Watermark Image Pre-Processing

The watermark image B(16x16) is first transformed into a string b of 256 bits i.e. b={ b1, b2, ..bm, bm+1, ..b256}. A 16x16 Hadamard matrix H16 is also generated. The rows of this matrix are used to spread the bit sequence in the watermark string b as follows:

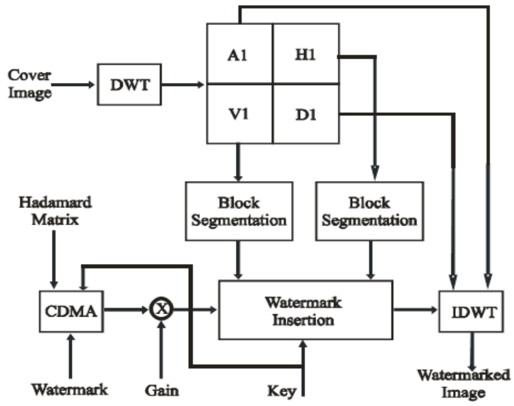


Figure 1: The watermarking process.

The sequence b(i); $1 \leq i \leq 256$ is segmented into 64sequences of consecutive 4-bit sequences. Let us designate the 64 segments as s1,s2,…sn-1, sn, sn+1 ,..s64 where sn={b4n-3,b4n-2,b4n-1,b4n} for $1 \leq n \leq 64$. Each string sn is spread into 16 new samples by using four rows of the H16 matrix in a CDMA procedure as follows.

$$w_n(j) = \sum_{i=1}^{4} (-1)^{s_{ni}} H_{ri}$$

For $1 \leq j \leq 16$ and where sn=(b4n-3, b4n-2, b4n-1, b4n). Using the private key, let the four randomly selected rows of H16 be: Hr1, Hr2, Hr3, and Hr4. Thus, a 4-bit sequence sn is transformed into a 16-element row vector wn.

3.3. The Watermark Insertion

The 64 watermark sequences; i.e. {w1,w2,…w64} are to be embedded in selected 4x4 blocks in the H1 and V1quadrants. Each quadrant has 1024 blocks of which only 32 will be embedded. A secret key is used to select the 32 blocks in H1 and equal number in V1. The procedure is as follows:
A pn-sequence of 1024 elements in the range [0,1] is generated and arranged into a 32x32 matrix POS(i,j) 1□i<32, and 1□j<32. A simple criterion is established to pick 32 elements in the POS(32x32) matrix. The positions of the selected elements identify the 32 out of 1024 blocks in H1 and in V1 which are to be embedded. The watermark embedding in the quadrants is an additive procedure as given in equation (2).

$$H1'_n = H1_n + kw_n \quad for\ 1 \leq n \leq 32 \qquad (2)$$

Where H1'n is the watermarked nth block in quadrant H1and H1n are the 4x4 DWT coefficients in block n and wn is the nth watermark sequence. The scalar k is a factor introduced in order to control the depth of the watermark. Similarly, the watermark embedding process in V1 quadrant is given in equation (3).

$$V1'_n = V1_n + kw_{n+32} \quad for\ 1 \leq n \leq 32 \qquad (3)$$

V1'n is the watermark coefficient, V1n the original and the same embedding factor k is used.

3.4. The Watermarked Image

The watermarked image quadrant H1 and V1 and the quadrant A1 and D1 are then transformed using the inverse Haar DWT to give a watermarked image Iw'.

4. WATERMARK DETECTION AND RETRIVAL

The received suspect image is decomposed into 1-level quadrants by using the Haar DWT as illustrated in Fig. 2. The secret key that was employed in the embedding
process is also used to identify the 4x4 DWT coefficients blocks in H1 and V1 that may contain the hidden watermark bits.

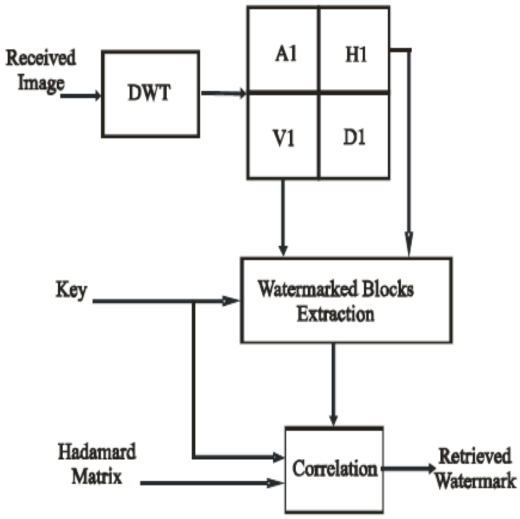


Figure 2: The watermark retrieval process

A 16x16 Hadamard H16, matrix is also generated and the secret key is used to identify the four rows that are to be
used. A correlation coefficient of the Hadamard matrix rows with a 4x4 DWT coefficient block that has been identified as possibly embedded with the watermark is computed as follows:
Let D(i,j), $1 \leq i \leq 4$ and $1 \leq j \leq 4$ be a 4x4 DWT
coefficients in block H1 or V1 that is suspect to be watermarked. These 16 coefficients are expressed as a row vector string X(j), $1 \leq j \leq 16$. The embedded watermark can be extracted one bit at a time by calculating the correlation coefficient between Xw and the corresponding matrix row as given below in equation (4).

$$C_i = \sum_{j=1}^{16} (H_{ri}(j) - H'_{ri}(j)).(X_w(j) - X'_w(j)) \qquad (4)$$

Where Hri(j) is the ith Hadamard matrix row with mean H'ri and where X'w is the mean of the DWT coefficients in Xw. The operator (.) is used to denote the dot product. The retrieved watermark bit is 0 if Ci is positive and 1 if Ci is negative.

5. EXPERIMENTAL RESULTS

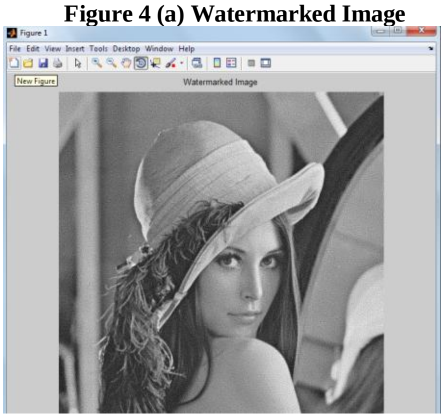
The cover image used in our experimental investigations is the 512x512 Lena image shown in Fig. 3(a). Similar results have been obtained with the 'Cameraman', 'Mandrill', and

'Peppers' standard images. The watermark is a 20x50 binary image shown in Fig. 3(b).

Figure 3. (a) The 512x512 Lena test image. (b) The 20x50 binary watermark.

The watermarked image and retrieved message is shown in Fig, 4(a) and 4(b).

Figure 4 (a) Watermarked Image



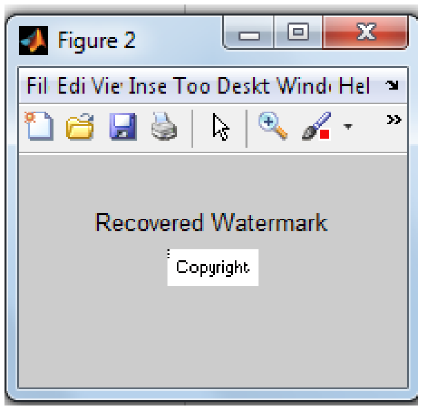


Figure 4(b) Recovered Message

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