# A CDMA Watermarking Scheme For Subspace Projection Based On PS Sequence

**N.VEDA KUMAR**
M.Tech Student , ES,
Dept of Electronics and Communication Engineering,
Holy Mary Institute of Technology &Science
Bogaram(v),Keesara(m),R.R.Dist,A.P,India.

**Y.DAVID SOLOMON RAJU**
Associate Professor,
Dept of Electronics and Communication Engineering,
Holy Mary Institute of Technology &Science,
Bogaram(v),Keesara(m),R.R.Dist,A.P,India.

**Abstract**

In this paper ,we introduced a novel method CDMA based watermarking scheme on the basis of orthogonal pseudorandom sequence subspace projection. In this paper a new idea to eliminate the correlation between the host image and the pseudorandom sequence in the encoding watermark extraction phase, compare the performance of wavelet and multi wavelet based CDMA watermarking scheme, and improve the robustness and message capacity of the watermarking scheme. In our proposed scheme implements the steps and performance testing under different attack conditions by a series of experiments. The experimental results observe the Host image under different attacks and show the higher robustness and increase the message capacity and achieve the high capacity to hide the data.

**Keywords-CDMA watermarking, high-capacity, subspace projection, wavelet transform,**

## I.INTRODUCTION

One of the present computer generations behind the increased use of copyright marking is the growth of the Internet which has allowed images, audios, video ,etc .Digital watermarking is the process of embedding information into a digital signal which may be used to verify its authentication or identification of the owners.

Basically digital watermarking is classified into two types first one is fragile and second one is robust. A digital watermark is called fragile it resists benign transformations, but the fragile watermarks commonly used to detect the informations and it can be easily changed. Fragile water marks are used in tamper detection, semi fragile watermarks are commonly used to detect malignant transformations.

A digital watermark is called robust if it resists a designated transformations. robust watermarks used in copy protection applications carry copy and no access control information.

Basically digital watermarking may be used for wide range of applications.

1.Data copy protection system

2.source tracking(different source elements get differently watermarked)

3.Broad cast monitoring(television news often contains watermarked video from international agencies)

A watermarking system is usually divided into three distinct steps , embedding, attack, detection. the watermarked signal is transmitted or stored, usually transmitted to anther person if the person makes the modifications is called the attacks. Detection is an algorithm which is applied to the attacked signal to attempt the extract the watermark form, the signal where the watermark is to be embedded is called the host image.

Canonical CDMA watermarking schemes have a serious drawback that the message capacity is limited. If we increase the message size and keep imperceptibility, then the bit error rate (BER) of the extracted watermark increases quickly. Most of the CDMA based schemes proposed so far have shown non-zero Bit Error Rate (BER) even if the watermarked image has not been attacked. In order to improve the message capacity researchers proposed wavelet domain CDMA watermarking schemes, decompose the host image into LL,LH,HL and HH sub bands and choose one or two of them for watermark embedding, In our paper we have to improve the robustness and message capacity of the respected watermarking scheme we use PS subspace projection. One application of watermarking is in copyright protection systems. In this use ,a copy device retrieves the watermark from the signal before making copy; the device makes a decision whether to copy or not, depending on the contents of the watermark.

In order to detect the presence or the absence of the watermark in the marked object. This kind of watermarking scheme is usually referred to as zero-bit or presence watermarking scheme. Some times this type of watermarking scheme is called 1-bit watermark, when 1 denotes the presence(0 and absence)of a watermark. The message is n-bit long stream $(m = m_1, m_2, .......m_n)$.

This type of schemes usually are referred to as multiple- bit watermarking or non zero bit watermarking schemes[6]-[9].

A watermark is a secure of knowing the algorithms for embedding and extracting help unauthorized party to detect or remove the watermark payload. Basically CDMA system, has different type of the noise signals or message signals are hidden into particular elements and it has a secure way of watermarking and increases robustness. In this type of the multiple signals that overlap and combine and separable. The separability is achieved by near orthogonal PS sequence prior to carrier modulation. Compare the performance testing of wavelet and multi wavelet based CDMA watermarking scheme that can improve the robustness and pseudorandom sequence has some correlation to host image representing locations to overcome these elements.

In this paper, we propose a high capacity CDMA watermarking scheme based on orthogonal pseudorandom sequence subspace projection. We eliminate the interference of the host image's contents by subspace projection. Experimental results show that the robustness and the message capacity are highly improved.

There is a vast literature on robustness and message capacity of watermarking schemes. But most of the early spread spectrum schemes deals only with '1-bit' systems that yield only a simple yes/no answer with respect to the presence of the watermark or visual logo. Multi-bit spread spectrum watermarking systems are not realizable until the CDMA principles are introduced into the area of watermark[11]-[13]. Even though, the message capacity of the watermarking schemes is limited. In their system has use wavelet and multi wavelet based CDMA systems has used and the host image is first transformed into sub bands and using balance multi wavelet to design high-capacity watermarking schemes.

## II. WATERMARKING SCHEMES

### A. The Channel Model of Canonical CDMA based Watermarking Schemes

Since discrete wavelet transform (DWT) is believed to more accurately models aspects of the Human Visual System(HVS) as compared to the FFT or DCT, watermark information are embedded in the wavelet domain for many CDMA based watermarking schemes. The host image is first transformed by orthogonal or bi orthogonal wavelets to obtain several sub band images (each sub band image consists of wavelet coefficients). Then some of them are selected for watermark embedding, Supposed sub band image I is chosen for watermark embedding and the message is represented in binary form $b = (b_1, b_2, ----b_l)$ Where $b_i \in \{0,1\}$ ,We first transform b into a binary polar sequence m of {-1,1} by the following formula

$$M_i = 1 - 2b_i, \quad i = 1,2,-----L \quad \text{............ (1)}$$

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According to the CDMA principles, the message M is encoded by L uncorrelated Pseudo sequence $\{s_1, s_2, ----s_l\}$ generated by a series key, such as m sequences, gold sequence, etc..

Since it is possible to make them orthogonal with each other, we simply assume that they are orthogonal unit vectors,i.e

$$\langle s_i, s_j \rangle = \delta_{i,j} = \begin{cases} 0, & i \neq j \\ 1, & i = j \end{cases} \quad \text{I,j=1,2....L} \ldots\ldots\ldots\ldots(2)$$

Where $\langle .,. \rangle$ denotes inner product operation. The pseudorandom noise pattern W is obtained as follows

$$W = \sum_{i=1}^{L} m_i s_i, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Which submerges the watermark message. Then the pseudorandom noise pattern W is embedded into the sub band image I as follows

$$I_W = I + \lambda W \ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Where $\lambda$ is a positive number, called the watermark strength parameter. Then an inverse wavelet transform is performed to obtain the watermarked image. In the watermark extracting phase, the watermarked image is transformed by the same wavelet transform that is used in the watermark embedding phase to obtain the sub band image that contains the watermark message.

$$I_W = I + \lambda W + n \ldots\ldots\ldots\ldots\ldots(5)$$

Where n is the distortion due to attacks or simply quantization errors if no other attack is performed. Then the orthogonal pseudo sequences{ $S_1, S_2 \ldots\ldots S_l$ }are generated using the key and their inner product between each $S_i$ and $i_w$ is computed.

$$\langle s_i, i_w \rangle = \langle s_i, I \rangle + \lambda m_i + \langle s_i, n \rangle \ldots(6)$$

The canonical CDMA based methods decide the sign of $m_i$ by computing the inner product on the left most of

$$m_i = \begin{cases} 1 \\ -1 \end{cases} \quad \textbf{otherwise}$$

Where denotes the estimated value of , This equivalent to neglecting of correlation between and the host image I and the correlation between s and the attack distortion n. When the message size is small, we can take a large watermark strength parameters $\lambda$ ,so we have no problem to neglect those small values. But when the message size is large, problem occurs. For the convenience of analysis, we ignore the third term in (6)at present.

$$\langle s_i, I_w \rangle = \langle s_i, I \rangle + \lambda m_i \ldots\ldots\ldots\ldots\ldots\ldots(8)$$

As the message size increases, the watermark strength parameter becomes smaller and smaller in order to keep the imperceptibility. So the influence of the host image's contents becomes more and more prominent as the message size increases. Experimental results also confirm this fact. So we must find a way to eliminate or reduce the interference of the host image so that we can improve the of the CDMA watermarking schemes considerably.

### A. HighCapacityCDMAWatermarking Scheme

In the previous subsection we have analyzed, the influence of the host image's content to the robustness of the canonical CDMA watermarking schemes. In order to eliminate this influence, we project the host image onto the linear subspace S generated by the orthogonal pseudorandom sequences.

$$P_s(I) = \sum_{i=1}^{L} \langle s_i, I \rangle s_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

If we keep the projection coefficients $\{ c_i = \langle s_i, I \rangle : i = 1, \ldots L \}$ as a secret key, then we can substrate $P_s(I)$ from the sub band

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image I before watermark extraction, there before watermark extraction, therefore ,we can decide the sign of $m_i$ computing.

$$\langle s_i, I_w - P_s(I) \rangle \approx \langle s_i, I + \lambda W - P_s(I) \rangle$$

$$= \lambda \langle s_i, W \rangle = \lambda m_i, \ldots\ldots\ldots\ldots(10)$$

Which is not affected by the host image's contents, and therefore, provides a more robust way for CDMA based watermarking.

### B. Watermark Embedding Process

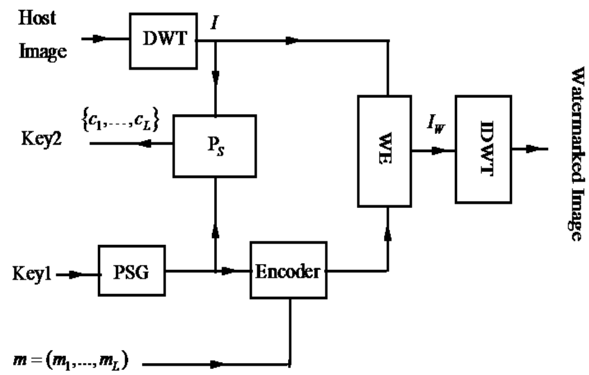
The watermark embedding process of the proposed high capacity CDMA scheme is the same as the canonical one expect for a preprocessing step of calculating the projection coefficients $\{c_i = \langle s_i, I \rangle : i = 1, \ldots L\}$ which should be kept a key for watermark extraction.

Here we give the watermark embedding steps:

Step1: decompose the host image into sub band images using orthogonal or biorthogonal discrete wavelet transform(DWT) and chose one or several sub band images I for watermark embedding.

Step2: generate the orthogonal pseudorandom sequences $\{s_1, s_2, \ldots s_L\}$ usingthesecretkey(key 1).

Step3: project the sub band images I onto the linear subspace S generated by the orthogonal pseudo sequences, and keep the projection coefficients $\{c_i = \langle s_i, I \rangle : i = 1, \ldots L\}$ as the second secret key (key2), which will be used in the watermark extraction phase.




Step 4: encode the watermark information using the formula(1)and to get(3) the pseudorandom noise pattern W.

Step:5 embed the pseudorandom noise pattern W into the sub band images I .

Step:6 perform inverse discrete wavelet transform (IDWT) to obtain the watermarked image.

### D. Watermark Extraction Process

Now we give the watermark extraction steps:

Step:1 decompose the received image into sub band images using the same wavelet transform as the one used in the watermark embedding phase, and choose the corresponding sub band images $I_w$ for watermark extraction.

Step:2 generate the orthogonal pseudorandom sequence $\{s_1, s_2, ----s_l\}$ usingthesecretekey(key 1).

Step:3 eliminate the projection component from $I_w$

$$I_W = I_w - P_S(I) = I_w - \sum_{j=1}^{L} c_j s_j, \ldots\ldots\ldots\ldots\ldots\ldots(11)$$

Where C are the projection coefficients kept in the second secrete key (key2).

Step:4extracttheembeddedmessage $m = (m_1, m_2, \ldots m_l)$ by correlation detection.

$$m_i = \begin{cases} 1 & \langle s_i, I_w \rangle > 0 \\ -1 & \text{,otherwise} \end{cases} \ldots\ldots\ldots\ldots(12)$$

Step:5transform the extracted message into the original watermark $b = (b_1, b_2, ....b_l)$.

$b_i = (1 - m_i) / 2$ **i=1,2……..L ………….(13)**

## III. PERFORMANCE TEST

We have performed a series of experiments to test the robustness of the proposed scheme. Seven 512x512 grayscale images are chosen as test images. The watermarks are binary sequences of different size. The pseudorandom number generators and we orthogonalize them by Cholesky decomposition method. Of course other choices of pseudo sequences such as m sequences, gold sequences may be more suitable for watermarking.

### A.Capacity VS Bit Error Rate (BER)

The first test we have performed is to test the relationship between message capacity and the bit error rate of the extracted watermark for both the canonical and newly proposed schemes. The bit error rate(BER) is calculated by the following formula.

$$BER = \frac{1}{mn} \sum_{i=1}^{m} \sum_{j=1}^{n} \left| W(i,j) - EXW(i,j) \right| \quad \text{.......(14)}$$

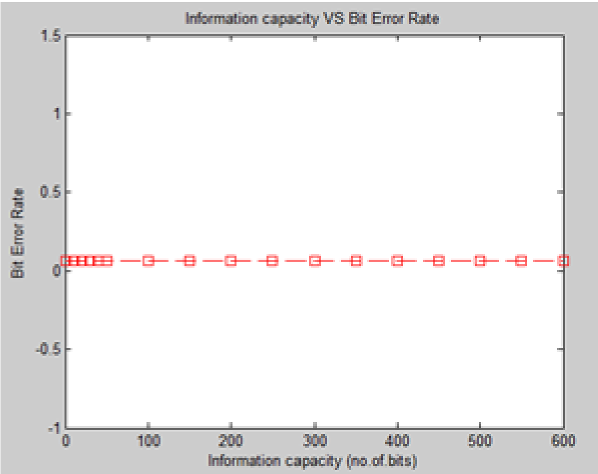
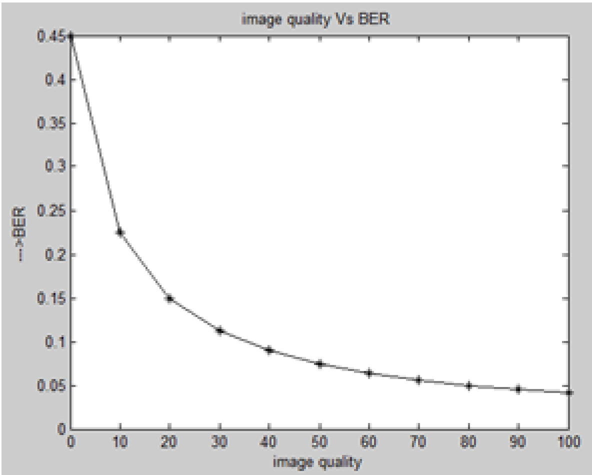



Fig.2 The relation ship between message capacity and the bit error rate of the extracted watermark.

Where W denotes the original watermark, EXW denotes the extracted watermark. In this test, we embed the watermarks into the lower resolution approximation image(LL) of the 2-level biorthogonal discrete wavelet decomposition of the test image using both canonical and the newly proposed CDMA based schemes, no attack is performed on the watermarked image except for quantization errors. Then extract watermarks from the watermarked image using corresponding watermark extraction schemes and compare the extracted watermark with the original one. The watermark size vary from 16 to1015,we have chosen 11discrete values for our test. For each watermark size values ,we perform the watermark embedding and extracting process on all7 test images, and calculate the average BER .In the whole test we carefully adjust the watermark strength parameters so that the peak signal to noise ratio (PSNR) of the watermarked image take approximately the same value for different watermark sizes and different test images.

The horizontal axis indicates the information capacity, the number of bits embedded in the test image. The vertical axis indicates the average BER.We see that as the information capacity increases the BER of the canonical CDMA based scheme increases and approaches to 0.5. But for the proposed scheme ,the bit error rate keeps to be zero until the message capacity takes the value of 1024 bits. Of course if the message capacity keeps on increasing ,the bit error rate cannot always be zero, it will increase and approach to 0.5 in the long run. On the hand, for the canonical scheme, if the message size is large ,the bit error rate is high even no attack is performed on the watermarked image. This phenomenon has not taken place in the tests for the proposed scheme yet. The reason is that the interference of the correlations between the test image and the pseudorandom sequence used for encoding the watermark message is cancelled in the proposed scheme. Proposed scheme has higher information capacity than the canonical CDMA based watermarking scheme when no attack other than quantization errors is performed.




**B. Robustness to Noise Attacks**

The second test is to test the robustness to noising attacks of both schemes. In this test, we first generate binary watermarks of capacity 128,256,512 and 1024 bits, then embed them into the 7test images using both watermark embedding schemes to generate 14 watermarked images, and then add Gaussian noise of different intensity to the watermarked images to generate the noising attacked images using corresponding watermark extraction scheme. The intensity of noising attack is measured by noise rate RI. i.e.

$$RI = \frac{\sigma}{R} \quad \text{..........................(15)}$$

We have added Gaussian noise with RI vary from 0.05 to 0.5 and calculated the average BER of the extracted watermark for each RI value and each value of watermark capacity, theBER-RIplotwith watermark capacity=1015, 512,256,128. We see that BER of the new scheme is much smaller than the one of the canonical scheme.

$$R = \max I(x, y) - \min I(x, y) \quad \text{..........(16)}$$

**C.Robustness to JPEG Attacks**

The third test is to test the robustness to JPEG attacks of both schemes. In this. We compress the watermarked images using JPEG compressor with quality factors vary from 100 to 1 before watermark extraction . The BER of both schemes under JPEG compression attacks with different quality factors. The horizontal axis indicates the quality factor that measures the extent of lossy JPEG compression, the smaller the quality factor, the higher compression extent. We see that the proposed scheme is highly robust to JPEG compression.

**D.Robustness to other Attacks**

We test the robustness to median filtering and jitter attacks of both schemes. In the median filtering test, we filter the watermarked image using a 5x5 median filtering template before watermark extraction, we first randomly drop a row and a column of the watermarked image, then randomly duplicate a row and column to keep the image size unchanged. This attack can destroy the synchronization of the watermark, which often leads to the failure of watermark extraction for many existing watermarking schemes. The experimental data are in list table I. We see that the proposed scheme is robust to both attacks but the canonical scheme is not.

Image quality VS BER for JPEG attacks of different attack intensity.=

**IV.CONCLUSIONS**

In this paper ,we propose a high-capacity CDMA watermarking scheme based on orthogonal pseudorandom sequence subspace projection. The proposed scheme eliminates the interference of the host image in the watermark extraction phase by subtracting the projection components ( on the linear subspace generated by the pseudorandom sequences) from the host image. So it is more robust than the canonical CDMA based scheme. We find that the proposed scheme shows higher robustness than the canonical scheme under different attack conditions. The expense of high robustness is that an additional key that consists of projection coefficients is needed for the watermark extraction. But this additional memory cost is worth while in many situations since it improves both robustness and security of the watermarking system. In the near future we will analyze and test the proposed scheme intensively and use it to design watermarking systems resistant to geometrical attacks and print-and-scan-attacks

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