



Correlation Based Watermarking Technique - Threshold Based Extraction

L.R. Gajriya, Mukesh Tiwari and Jaikaran Singh

Department of Electronics and Communication Engineering, SSSIST, Sehore, (MP)

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ABSTRACT : In this paper, we have suggested the correlation method for the digital image watermarking . The method is used for the copyright protection as well as proof of ownership. In this paper we have used characteristics of PN sequences for embedding and extraction of message data and calculated different parameters.

Keywords: Digital image watermarking, image copyright protection, spatial domain watermarking, PN sequences, correlation method.

I. INTRODUCTION

In case of a dispute, identity was established by either printing the name or logo on the objects. But in the modern era where things have been patented or the rights are reserved (copyrighted), more modern techniques to establish the identity and leave it untampered have come into picture.

Unlike printed watermarks, digital watermarking is a technique where bits of information are embedded in such a way that they are completely invisible. The problem with the traditional way of printing logos or names is that they may be easily tampered or duplicated. In digital watermarking, the actual bits are scattered in the image in such a way that they cannot be identified and show resilience against attempts to remove the hidden data.

A watermarking system is made up of a watermark embedding system and a watermark recovery system. The system also has a key which could be either a public or a secret key. The key is used to enforce security, which is prevention of unauthorized parties from manipulating or recovering the watermark. The embedding and recovery processes of watermarking are shown in Figure 1 and 2 respectively

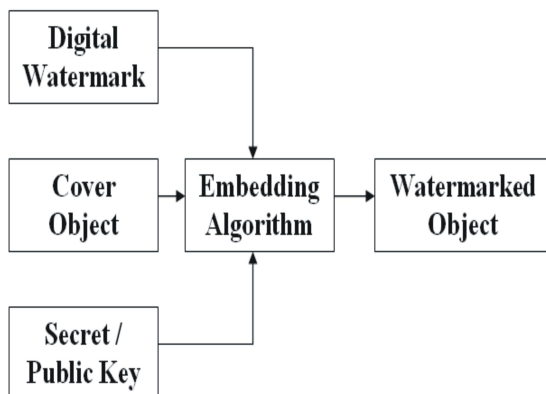


Fig. 1. Embedding process of watermarking.

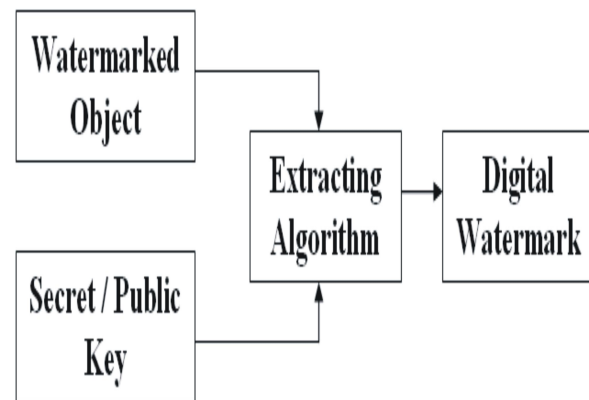


Fig. 2. Recovery process of watermarking.

II. REQUIREMENT OF CORRELATION METHOD OF WATERMARKING

The early researches used least significant bit method for watermarking. The only disadvantage was, if a small portion of watermarked image was decoded then also the message was been extracted.

That means the watermarked data was less secured. In correlation method, more security is added using PN sequence and a Key.

III. THE PN SEQUENCES

A pseudorandom noise (PN) sequence is a sequence of binary numbers, *e.g.* ± 1 , which appears to be random, but is in fact perfectly deterministic. The sequence appears to be random in the sense that the binary values and groups or runs of the same binary value occur in the sequence in the same proportion.

Pseudorandom sequences can be generated by using a Linear Feedback Shift Register (LFSR) circuit *i.e.* when a shift register has a non-zero initial state and the output is fed back to the input, the unit acts as a periodic shift

register. Figure 3.17 shows LFSR that uses a three stage shift register where the second and the third cells are tapped and modulo-2 added and fed back to the first stage.

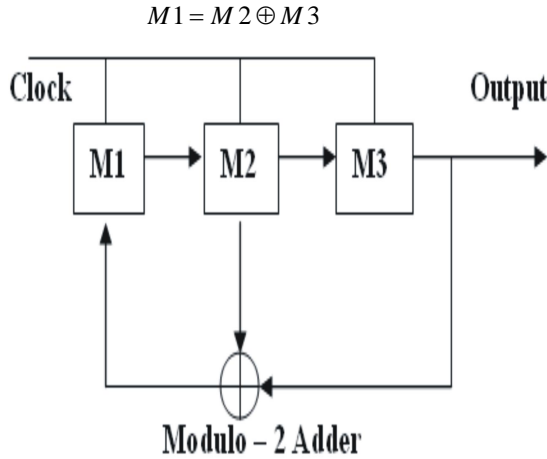


Fig. 3. Linear Feedback Shift Register.

The contents of the shift register are shifted with each clock pulse. The output of the LFSR is taken from the m3 stage.

The output from the Linear Feedback Shift Register repeats periodically. In general the period is

$$N = 2^n - 1$$

where, N is the period and n is the number of shift registers.

IV. PROPERTIES OF PN SEQUENCES

Maximum length sequences have the following properties

- Except the zero state, all of the $2n$ possible states will exist during the sequence generation.
- Balance Property: For each sequence generated by the feedback shift registers the number of ones and zeros is approximately equal.
- Run Property: A run is defined as a sequence of single type of digit. Any maximum length sequence will have one half of its runs of length 1, one quarter of its runs of length 2, one eighth of its runs of length 3, so on. Or the relative frequencies of runs "0 0 0 0 0" and "1 1 1 1 1" of length n approximately equal $1/2^n$ each.
- Shift Property: The number of agreements and disagreements between each sequence and its cyclically shifted versions are approximately the same.

1 1 1 0 0 1 0
0 1 1 1 0 0 1
- + + - + - -

Consider + as agreement and - as disagreement. Then, the number of agreements *i.e.* + is approximately the same as the number of disagreements.

- Autocorrelation Property: The autocorrelation of ML sequence is single peaked. The auto correlation of any sequence S can be defined as follows:

$$R_{ss}(k) = \frac{1}{N} \left[\sum_{n=0}^{N-1} S_n * S_{n-k} \right]$$

- where R_{ss} is auto correlation of S , S_{n-k} is the cyclic shift by k .

$$R_{ss}(k) = -1/(2n - 1) \text{ if } k \neq N;$$

$$R_{ss}(k) = -1 \text{ if } k = N$$

- Cross-correlation Property: The cross-correlation property provides a measure of resemblance between two different sequences. The cross-correlation of these two sequences is defined as follows:

$$R_k(a,b) = \left[\frac{1}{N} \sum_{n=0}^{N-1} a_n * b_{n-k} \right]$$

The two sequences are said to be orthogonal if the cross-correlation between them is equal to zero.

V. CORRELATION TECHNIQUE-THRESHOLD BASED CORRELATION

The technique for watermark embedding in the spatial domain is to exploit the correlation properties of additive pseudo-random noise patterns as applied to an image.

Pseudo noise sequences are a good tool for watermarking because of the following reasons

- PN generator produces periodic sequences that appear to be random.
- PN sequences are generated by an algorithm that uses an initial seed.
- PN sequence generated is actually not statically random but will pass many tests of randomness.
- Unless the algorithm and seed are known, the sequence is impractical to predict.

A. Embedding Process

A pseudo-random noise (PN) pattern $W(x, y)$ is added to the cover image $I(x, y)$, according to the equation shown below:

$$I_w(x, y) = I(x, y) + k * W(x, y)$$

where $I(x, y)$ – Original Image

$W(x, y)$ – Pseudo-random noise (PN) pattern

K – Gain Factor

$I_w(x, y)$ – Watermarked Image

Here Increasing k increases the robustness of the watermark at the expense of the quality of the watermarked image. Fig. 4 shows the block diagram representation of the process.

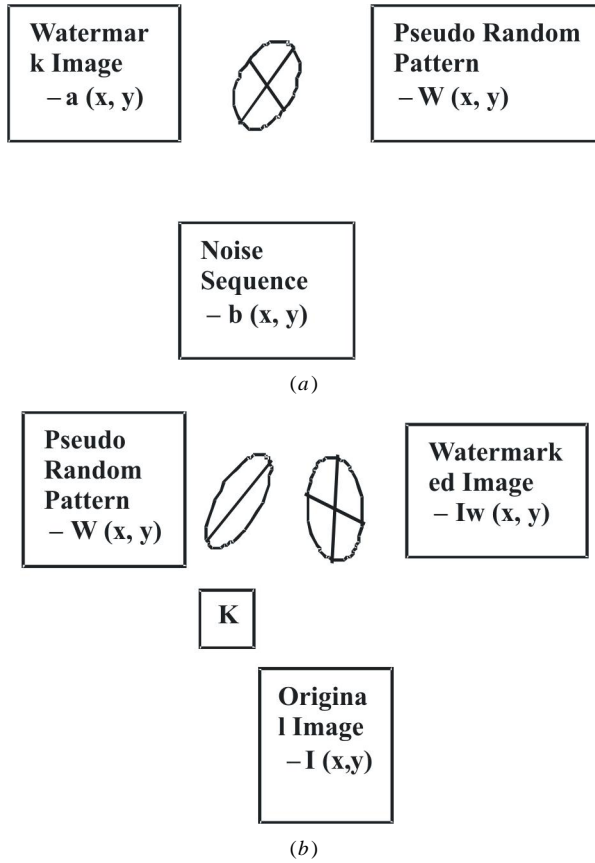


Fig. 4. Embedding Process-Threshold Based Correlation (a) Generation of Pseudo Random Sequence (b) Watermarking the original Image with PN sequence.

Here watermark image $[a(x, y)]$ works as the information bearing data signal and PN sequence. $[b(x, y)]$ as the spreading signal. The desired modulation is achieved by applying both the watermark image and the PN sequence to a product modulator. The resultant signal $W(x, y)$ is a pseudorandom noise pattern that is added to the cover image $I(x, y)$ to produce the resultant watermarked image $I_w(x, y)$. Hence

$$I_w(x, y) = I(x, y) + k * W(x, y)$$

$$I_w(x, y) = I(x, y) + k * [a(x, y) * b(x, y)]$$

Key and the gain are fixed before the generation of PN sequences. The watermark is then converted to a string of zeroes and ones. A PN sequence of size equal to the original cover image is generated for each of the pixel in the watermark vector. If the pixel in the watermark vector is zero then the PN sequence with appropriate gain is added to the cover image else zeroes are added. For retrieval of the watermark the PN sequences are generated with the same key as used during the embedding process. The correlation is calculated between the generated PN sequence

matrix and the watermarked image for each of the pixels in the watermark string and if it exceeds a particular threshold then the watermark is said to be detected.

The robustness of the watermarked image increases as the gain K increases. But, with the increase in the gain K , there is a reduction in the quality of the final watermarked image. Therefore, there is a tradeoff between the robustness and the quality of the image.

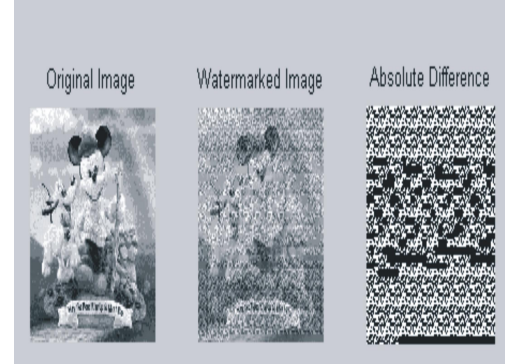


Fig. 5. Threshold Based Correlation-Embedding process.

B. Extraction Process

To recover the original watermark $a(x, y)$, the watermarked image $I_w(x, y)$ is multiplied at the receiver again with a pseudo noise sequence $b(x, y)$ which is an exact replica of that used for embedding the data. Figure 6 shows the block diagram representation of the extraction process.

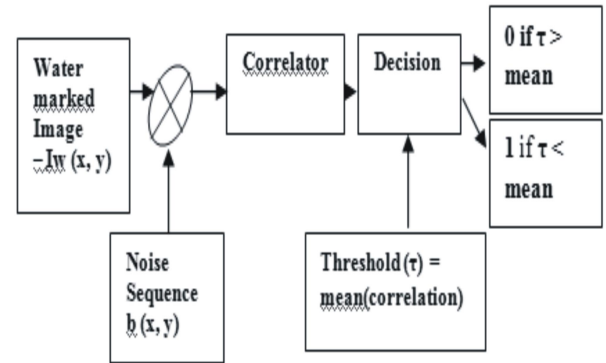


Fig. 6. Extraction Process-Threshold Based Correlation.

Here the output of the multiplier is given by:

$$\begin{aligned} C &= I_w(x, y) * b(x, y) \\ &= [I(x, y) + k * ([a(x, y) * b(x, y)])] * b(x, y) \\ &= I(x, y) * b(x, y) + k * [a(x, y) * b^2(x, y)] \end{aligned}$$

The above equation shows that the watermark image $a(x, y)$ is multiplied twice with the noise signal $b(x, y)$, whereas the unwanted or the cover image $I(x, y)$ is multiplied only once with the noise signal. So $b_2(x, y)$ becomes 1 and the product $I(x, y) * b(x, y)$ is the unwanted

noise signal that can be filtered out during the process of correlation by setting the threshold as mean of correlation. Hence, at the receiver we recover the watermark image $a(x, y)$. Fig. 7 shows the recovered message.

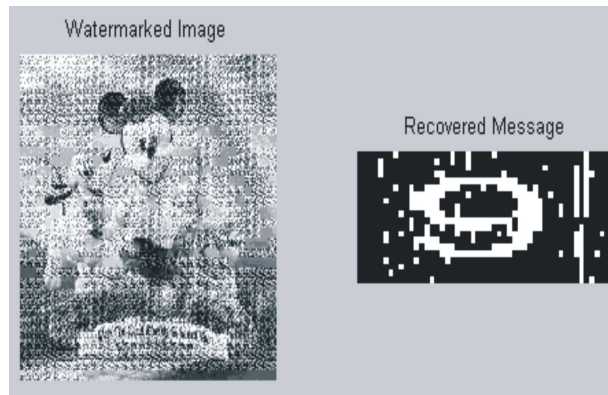


Fig. 7. Threshold Based Correlation-Extraction process.

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