QUANTIZATION WATERMARKING INTEGRATED IN A WAVELET COMPRESSION SYSTEM

A. Makhloufi, A. Ouled Zaid, A. Bouallegue and R. Bouallegue

SYSCOM IT-03 – ENIT – El Manar University
Le Belvédère, 1002 Tunis, Tunisia

ABSTRACT

There are several advantages to combine, at one end the image coding and watermark embedding scheme and at the other end, the image decoding and watermark extraction. In this paper, we present a blind watermarking approach based on quantization index modulation, incorporated in low bit rates wavelet image coder. To encode the binary message, the watermark is placed in the transformed image prior to the uniform quantization used in the compression algorithm. We also show that, by re-using the coding wavelet domain for watermark, the proposed watermarking scheme exhibits a high robustness with respect to compression attacks.

1. INTRODUCTION

The development of the numerical broadcasting media leads to an easier manipulation of the original documentations, their duplications even illegal copyrights. Hence, a system of security is needed to control the diffusion of the original documentations and protect the copyrights of the authors. The recent studies focus on the digital watermarking techniques. Digital watermarking consists in embedding an imperceptible message into the host multimedia signal without introducing perceptual distortions. Many watermarking schemes have been established. We can classify them according to techniques used to insert the watermark and methods used to recover the watermark. In the first case, there are tow techniques the additive mode where the watermark signal is added to the original data of the medium [2] [1], the other one is called substitutive method where the original data, itself, is modified to encode the message citeMeerwald. Secondly, in the extraction stage, we discern tow techniques, the ones that extract the message from the watermarked image without need to the un-watermarked host image, these schemes are called blind watermarking citeMeerwald, and the other techniques need to subtract the original data from the watermarked ones to get the message, these schemes are non-blind watermarking.

In our study, we have note that although there is a considerable development of the digital network such as Wide World Web even with the huge capacities of storage, digital media stay exchanged in a compressed form [2]. Thus, we propose a new blind scheme of watermarking digital images integrated in a wavelet compression system based on substitutive technique.

The paper is organized as follows. In section 2, we give an overview of the watermarking approaches. Then, In section 3, we present our hybrid coding scheme. In section 4, we describe the watermark approach that we integrated in wavelet coding process. Finally, in section 5, we present results and discussion about robustness against compression attacks.

2. QUANTIZATION WATERMARK

In our study we aim to extract the message from the watermarked image without needs to the unmodified host image, we dubbed blind watermark [2]. This scheme is used in additive and substitutive watermarking techniques [1] cite-Gaetan. In the first case, many proposed watermarking techniques add a spread spectrum signal to the host image [3], because the unmodified host image can not be subtracted from the received data in blind schemes, this leads to interference when correlating the watermark with the received signal, so the detection of the watermark is threatened to be loosed or confused with the signal of the image itself [2] [3]. However, substitutive watermark known as quantization watermark [1] consists on coding the message by modifying the original data itself [2] [1]. So, the analyses of the received data allow reconstruction of the message [3]. Therefore, when extracting the message in blind schemes, we note more less errors in the quantization watermark than the additive ones [1] [2]. As a result, we choose quantization watermarking scheme in our blind algorithm.

There are many techniques based on quantization watermark [1] [4] [5]. The simplest way is to change the LSB bit of the pixel that encodes the message [5]. On one hand, this method doesn’t introduce a perceptual distortion in the host image, but, in other hand, it suffers from a weak robustness. Eggers [6] explains a new technique of quantization watermark called ?quantization index modulation? (QIM) this method consists on introducing a signal that permit to
reduce distortion between quantized/reconstructed data and the original ones [2]. The same signal can serve as a key to extract the message [2]. This method is very robust to attacks such as lossy compression, and gives good results when extracting the watermark [1]. More detail about the method will be given in section 4.

3. CODING SCHEME

The wavelet coder [7] decomposes the image into $n$ levels ($n = 1..5$). The coarser image carries on the low frequencies, thus means the most significant data of the transformed image, so it will not be severely quantized by the coder, that is to keep the minimum error of reconstructed data when decoding the compressed image. Hence, we chose to embed the watermark in the coarser image.

The image is first transformed in DWT domain, and then the watermark is embedded, prior to the uniform quantization used by the lossy compression in the wavelet coder (see 1). All DWT coefficients of the coarser image are selected then quantized and reconstructed accordingly to the chosen method mentioned in section 4. Each coefficient code one bit of the message the coded coefficients can be chosen randomly and keep their emplacement as a secret key. To make the method more robust, we can dived the coarser image into vectors of coefficients, each vector will be quantized to encode one bit of the message.

Fig. 1. watermark embedding in wavelet image coder.

4. WATERMARKING STRATEGY

4.1. Watermark embedding process

Our proposed method is derived from the QIM applied in a wavelet transform (see 2). Let $b = \{b_1, ..., b_i, ..., b_n\}$, $b_i \in \{0, 1\}$ be the binary message to encode, we consider a uniform quantizer with a step size $\delta$, then after quantization, the quantized coefficient is shifted as follows:

- to encode 0

$C_0 = c + \frac{\Delta}{4}$ if $c > 0$
$C_0 = c - \frac{\Delta}{4}$ otherwise

(1)

- to encode 1

$C_1 = c + 3\frac{\Delta}{4}$ if $c > 0$
$C_1 = c - \frac{\Delta}{4}$ otherwise

(2)

where $c$ is the quantized coefficient and $C$ is the obtained watermarked coefficient. $c$ is moved to take the value of $C_0$ when it encoding a 0 or $C_1$ if encoding a 1. The embedding precision is about $\frac{\delta}{7}$.

Fig. 2. Quantization watermark strategy.

4.2. Watermark extraction process

The extraction of the watermark is the reverse of the embedding process. In this stage, the received watermarked image is first transformed to DWT and re-decomposed in $k$ levels. Secondly, the coarser image coefficients are quantized to $Q_1$ and $Q_2$ as follows:

$Q_1 = \begin{cases} 
\frac{(C' + \frac{\Delta}{2})}{\Delta} & C' \geq 0 \\
\frac{(-C' - \frac{\Delta}{2})}{\Delta} & otherwise 
\end{cases}$

(3)

$Q_2 = \begin{cases} 
\frac{C'}{\Delta} & C' \geq 0 \\
\frac{C'}{\Delta} & otherwise 
\end{cases}$

(4)

where $C'$ is the wavelet coefficient of the coarser image. $\Delta$ is the same step size used in the embedding stage. In this
case, we measure the difference between the reconstructed coefficient $Q_1$, $Q_2$ and the one before quantization ($C'$) and we make a decision:

$$
\text{if } (C' - (Q_1 \times \Delta) < C' - (Q_2 \times \Delta)) \text{ then } b_i = 1 \\
\text{else } b_i = 0
$$

(5)

5. EXPERIMENTAL SETUP AND RESULTS

![Diagram](image)

**Fig. 3.** PSNR/Rate curves using our watermarking method combined to wavelet image coder with different decomposition levels: (a) 3 levels, (b) 4 levels and (c) 5 levels.

5.1. Coding performance

To show the effect of the watermark on coder performance we integrate our algorithm in a wavelet compression coder. The simulations were carried out on gray-scale Lena image of size $512 \times 512$.

The results of our experience show that effect of the watermarking on coding scheme in term of PSNR varies with wavelet decomposition levels. Figure 3 depicts Rate-PSNR results by using: 3 levels of decomposition (3-a), 4 levels of decomposition (3-b) and 5 levels of decomposition (3-c). Based on these figures, we can conclude that results with 3 levels of decomposition is the worst one. This is due to the fact that low frequency sub-band contains more information compared to four and five levels wavelets decomposition coder. Hence, watermarking effects and quantization errors can appear in the image which is fed in the coder. Results with 4 levels of decomposition is seen to perform better than 3 levels of decomposition, but worse than 5 levels of decomposition which is the best choice. This is explained as follows: there is a tradeoff in the choice of wavelet decomposition levels: If very high wavelet decomposition level is chosen, the initial content of the texture is very small at the corser image, and the embedded watermark is not very discriminant. However, it limits the binary message length: for example, in the case of 512x512 image, the message length is up to 256 bits. This is why, the best choice is with 4 wavelet decomposition levels.

5.2. Robustness

Note that, for robustness comparison purposes, all methods here have been restricted to wavelet coding based on 4 levels of dyadic wavelet decomposition. To evaluate the robustness of the watermark scheme we have carried out tests which consist on computing percentage of the correct binary symbols for different bitrates and different step sizes ($\Delta = 64, \Delta = 128$). From 4 we can see that the totality of the watermark message is retained from high to low bitrates. However, the binary message risks seriously to be lost in lower bitrates, less than 0.1 bpp. The final comparison may be more relevant: It turns out that the watermarking procedure with higher step sizes ($\Delta = 128$) is seen to obtain a large improvement over the same procedure applied with lower step sizes ($\Delta = 64$). This is attributed to the fact that high step sizes contribute to the increase of the embedding precision, which is equal to $\frac{\Delta}{2}$ (see 4).

We are thus able to reconstruct the right binary message by using a high step size. Therefore, this algorithm seems to be a good basis for obtaining robust watermark scheme against compression attacks.
6. CONCLUSION

We presented a new blind watermarking scheme based on quantization in the wavelet domain. This technique is integrated in a wavelet compression coder. The coder decompose the image in subbands, hence, to keep the most minimum error in decompressed data, the coder will do a fine quantization to the wavelet coefficients in the coarser image, we exploit this criterion to insert the watermark in the coarser subband. Our proposed method was found to achieve a high robustness to compression attack at low bit rates.

7. REFERENCES


