A Quasi Blind Watermark Extraction of Watermarked Natural Preserve Transform Images

M. F. Fahmy*, O. M. Fahmy and G. Fahmy**

* Department of Electrical Engineering, Assiut University, Egypt
** German University in Cairo, Egypt

Email: fahmy@aun.edu.eg                                                                   Email : gamal.fahmy@guc.edu.eg

Abstract
The Natural Preserve Transform (NPT) has been presented as a tool for fuzzy logic watermarking. This paper describes a new image watermarking technique based on Naturalness Preserving Transform (NPT). The proposed watermarking scheme uses NPT to encode a grey scale watermarking logo image or text, into a host image at any location. This paper presents efficient non-blind and quasi-blind watermark extraction techniques. In the quasi blind case, the extraction algorithm requires only very few information about the original image that is already conveyed by the watermarked image. Moreover, the proposed scheme does not introduce visual quality degradation into the host image. The performance and robustness of the proposed technique are tested by applying common image-processing operations such as cropping, noise degradation, and image compression. A quantitative measure is proposed to objectify performance; under this measure, the proposed technique outperforms most of the recent techniques in most cases.

I. Introduction
With the widespread use of the internet and the rapid development of multimedia, the need for copyright protection became very important. A variety of image watermarking methods has been proposed [1-6], where most of them are based on the spatial domain [1] or the transform domain [2]. Unlike traditional watermarking techniques that rely on text data, this paper presents a grey scale logo watermarking technique, where we have a recognizable mark that is more convincing and visually meaningful than a random numerical sequence. It will also improves the trustworthiness of identification or security for non-technical arbitrators [3]. A watermark has to include 3 main properties, robustness, visibility, and capacity [4], embedding the watermark in the image would definitely amount to a tradeoff between these 3 properties. In [5], a composite approach for blind grayscale logo watermarking, is presented. This approach is based on the multi-resolution fusion principles to embed the grayscale logo in perceptually significant blocks in wavelet subband decompositions of the host image. However, in spite of its high complexity, the technique failed with the cropping attacks. In [6], a curvelet-based watermarking technique has been proposed for embedding grey-scale logos. However, its preliminary results are not impressive as the normalized correlation (NCORR) between the original and extracted logos with most of the watermarking attacks, does not exceed 0.91. In [7,9], an alternate novel watermarking scheme has been proposed. It is based on making use of the Natural Preserve Transform, NPT. The NPT is a special orthogonal transform class that has been used to code and reconstruct missing signal portions [8]. Unlike previous watermarking schemes that use binary logos, NPT amounts to evenly distributing the watermarking gray scale logo or text, allover the host image. The method assumes the prior knowledge of the host image, for watermark extraction. In [10-11], an efficient fast least squares technique is proposed for NPT watermark extraction, to remedy the slowly convergent iterative technique originally proposed in [8-9].

In this paper, a quasi blind watermark extraction technique is presented. The method is quasi blind in the sense that the extraction technique requires only a very few information about the original host image that is needed for the complete recovery of both the host image and watermarking logo. This needed information, is conveyed by the watermarked image itself without seriously degrading its quality. Illustrative examples are given to show the quality of the watermarked images, as well as the extracted watermarking logo, and its performance in the presence of attacks. In fact, apart from its simplicity, the method is virtually insensitive to cropping attacks and performs well in case of compression and noise attacks. The paper is organized as follows. Section II, covers all mathematical background needed for our proposed watermarking technique using NPT. Section III, briefly reviews the NPT non-blind extraction technique and describes how quasi blind case is implemented. Experimental Procedure and simulation results are presented in section IV, along with conclusions in Section V.

II. The Natural Preserving Transform, NPT

The Natural Preserving Transformation NPT [7-9], is defined by

\[ \psi = \alpha I_N + (1 - \alpha) H \]  

(1)

Where \( I_N \) is an \( N \times N \) order identity matrix, \( H \) is any orthogonal transform, like Hadamard, DCT, Hartley or any other orthogonal transform. \( 0 \leq \alpha \leq 1 \) Throughout this paper, we use the 2-D Hartely transform, defined by...
\[ h(k, j) = \frac{1}{\sqrt{N}} \left( \cos \left( \frac{2(k-1)\pi}{N} \right) + \sin \left( \frac{2(j-1)\pi}{N} \right) \right) \]  

(2)

due to its circular symmetry performance.

For an image \( S \) (of size \( N \times N \)), when NPT is applied in a symmetrical manner, the transformed image \( S_t \) is given by

\[ S_{tr} = \psi S \psi^{-1} \]  

(3)

Clearly, when \( \alpha = 1 \), the transformed image is the original image. Whereas for \( \alpha = 0 \), it will be the orthogonal projection. The transformed image has PSNR of the order

\[ 20 \log_{10} \left( \frac{\alpha}{1-\alpha} \right) \]. So, in order to ensure high PSNR, one should have \( 0.9 \leq \alpha < 1 \). The original image can be retrieved from the transformed image \( S_{tr} \), using

\[ S = \psi^{-1} S_{tr} \psi^{-t} \]  

(4)

If \( H \) is symmetric, as in case of using Hadamard or Hartly transformation, we can easily show that

\[ \psi^{-1} = \psi \left( \frac{\alpha}{2\alpha-1} \right) \]  

(10)

which in conjunction with Eq.(6) yields

\[ \psi_{12} x_k = [A_{0w} \phi]_k - \psi_{11} S_{0,k} \]  

(6)

\[ 1 \leq k \leq N \]  

(11)

The \( S_{0,k} \) are obtained by solving a set of \( r \) linear equations satisfying the following condition:

\[ \psi_{12} = \left[ \begin{array}{c} \psi_{11} \\ \psi_{12} \end{array} \right] \]  

2. For every column \( k \) of \( S_{0,:}(:,k) \), \( 1 \leq k \leq N \), form the vector

\[ v = \left[ S_{0,k} \right], S_{0,k} = S(1:N-r,k) \]  

(7)

3. Having carried out the preceding steps for the \( N \) columns of \( S \), form \( X = [x_1 \ x_2 \ ... \ x_N] \). Then, the water mark logo is \( w_1 = X\phi \)

b- The Quasi Blind Case:

When the prior knowledge of the host image \( S \) is not available, the following quasi blind technique is proposed for watermark extraction of an NPT-based watermark image. For simplicity, we consider the blind extraction of the transformed image of the host image.

\[ A_w = \psi(\alpha) S_{wm} \psi(\alpha) = \left[ \begin{array}{c} A_{0w} \\ z \end{array} \right] \]  

(9)

After registering the watermark all over the host image and in order to make the watermarking logo hardly visible, we modify \( A_w \) to \( A_{wm} = \left[ \begin{array}{c} A_{0w} \\ S(N-r+1:N,:) \end{array} \right] \), which means replace the logo part of the image with the corresponding part of the original image (without the watermark). In [10], a more simple embedding technique is proposed. It amounts to replacing part of the host image by the logo image. For simplicity, the logo is embedded in the upper left corner. So, if the host image is partitioned as \( S = \left[ \begin{array}{c} S_{11} \\ S_{21} \end{array} \right] \), then the embedded image is \( S_{wm} = \left[ \begin{array}{c} w \\ S_{12} \\ S_{21} \end{array} \right] \). Each of the embedding techniques, either resizing the logo to fit a few lines in the host image (bottom) or embedding it as a box (top), has its own advantages. Where the first one is more suitable in comparisons with text watermarking and needs less rows to be known at the receiver for extraction and the second one is more robust as the corner has more energy.

At the receiver, the watermarking logo \( w \) can be easily extracted, if \( \alpha \), the host image \( S \) as well as the type of orthogonal transformation used are known. In [10-11] a fast least squares technique is proposed for watermark extraction. It is briefly summarized as follows:

1. Partition \( \psi = \left[ \begin{array}{c} \psi_{11} \\ \psi_{12} \end{array} \right] (N-r) \downarrow r \)  

2. For every column \( k \) of \( S_{0,:}(:,k) \), \( 1 \leq k \leq N \), form the vector

\[ v = \left[ S_{0,k} \right], S_{0,k} = S(1:N-r,k) \]  

(11)

\[ 1 \leq k \leq N \]  

(8)

Where \( \downarrow r \) means the \( k^{th} \) column of the matrix.
\[ V_k^t \psi_{12}(:, j) = 0 \quad 1 \leq j \leq r \]  
(12)

Moreover, since \( \psi_{12} \) is an \((N-r)xr\), then its rank equals \( r \). Consequently, the rank of the matrix \( V \) is \((N-2r)\).

3. Pre-multiply Equation (10) by \( V^t \) to yield

\[ V^t A_{w} \phi = V^t \psi_{11} S_1 \]  
(13)

As the rank of \( \psi_{11} \) is \((N-r)\), the rank of \( V^t \psi_{11} \) is \((N-2r)\).

So, to have a unique solution of Equation (12), \( r \) arbitrary parameters of every column of \( S_1 \) have to be known at the receiver. This can be achieved if in the watermarked image \( A_w \), we choose the matrix \( z \) (Equation (6)), to be \( S(N-2r+1:N,:) \) instead of \( S(N-r+1:N,:) \). Having obtained \( S_1 \) as the unique solution of Equation (12), \( w_j \) is extracted as in the non-blind case, and subsequently reshaped to regain the original watermark \( w \).

IV. Experimental Procedure

a. Watermark embedding

We consider the embedding of Assiut University logo, onto Lena image, using the top and bottom embedding techniques. The grayscale Assiut University logo has a size of 87x60. The complete Harley orthogonal transformation is used with \( \alpha = 0.99 \). In the bottom embedding case, the logo is embedded as 21 bottom rows, as described earlier. Fig. 1 shows the original logo, as well as the NPT watermarked image \( A_w \) and the masked watermarked image \( A_{wm} \) for the top and bottom embedding cases. The watermarked PSNRs are 39.6 and 39.85, respectively.

b. Quasi Blind case

The quality of extraction is judged by computing the normalized correlation \( NCORR \) between the original and extracted logo, i.e.

\[ NCORR = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} w_{ij} w_{ex,ij}}{\|w\| \|w_{ex}\|} \]  
(12)

where \( w_{ex} \) is the extracted watermark.

We selected the 256x256 Cameraman image as the host image, and resized the Lena image to be the logo image(32x32), which makes it possible to reshape it and embed it to the last 4 rows of the host image as explained in section IIIa, with \( \alpha = 0.985 \). Fig.2 shows \( A_{wm} \), the reconstructed Cameraman image as well as the extracted logo, Lena image. The watermarked PSNR is 32.58 dB, with \( NCORR = 1 \).

c. Cropping, Compression and Noise

We consider half cropping the watermarked Lena image \( A_{wm} \). The cropped part is filled with white pixels. Fig. 3, shows the watermarked cropped image together with the extracted logo. \( NCORR = 1 \), a property that is shared by the other two embedding techniques.

To verify that the watermarking logo can be easily identified even in presence of compression, the watermarked image \( A_{wm} \) is compressed using SPIHT coder/decoder algorithm implemented with different number of bits per pixel (bpp). Fig. 4, compares the non-blind performance of \( NCORR \) of the extracted logos versus compression, (bpp) used to represent the watermarked Lena image \( A_{wm} \) for the three embedding techniques top, bottom, and optimal location of the logo (by mean square error minimizing of the watermarked image and the original image) evaluated for different values of \( \alpha \) (a). These results indicate that, embedding the logos near the corners of the host image improves its robustness to compression attacks, since the Hartley matrix concentrates the energy near the 4 corners of the host image. The results also indicate that the top embedding case competes well with other techniques, especially when decreasing \( \alpha \).

To show the robustness of the proposed method to noise attacks, \( A_{wm} \) is corrupted with salt and pepper noise with \( D = 0.2 \). Fig.5, compares the normalized correlation of both top and bottom embedding, when the watermarked image is mixed with AWGN with different powers. In this experiment, the extracted watermark has a normalized cross correlation of 0.8968, which outperforms [4-5].

V. Discussion and Conclusion

The paper presents how logos and watermarks can be efficiently embedded using an NPT-based technique. The watermark is highly invisible and robust against cropping, and compression attacks. An efficient fast least square algorithm is also described for watermark extraction, for both the non blind and quasi blind cases. In the non blind case, the extraction algorithm assumes prior knowledge of the host image, whereas in the quasi blind case only very few information of the host image is needed.

VI. Acknowledgment

This work is funded by the Ministry of Communication and Information Technology, Egypt, ITIDA

VI. References


Fig. 1 Top and bottom Embedding PSNR =39.6 and 39.85 dB, respectively.

Fig. 2 Left: NPT watermarked image \( A_{wm} \) Right: Blind reconstructed host image Bottom: Extracted 32x32 Lena logo

Fig. 3 Cropping performance of optimum location embedding, together with the extracted, logo.

\( \alpha = 0.99 \), \( NCORR=1 \)

Fig. 4. Compression performance of the 3 embedding schemes

Fig. 5. AWGN of top and bottom embedding