Multiple Successive Watermarking Scheme Based on Wavelet Transform

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Abstract: Multiple watermarks is to convey multiple sets of information, proposed to suit similar or differing objectives, used to increase robustness with many different methods; the embedded information is not easily lost. The successive watermarking method is useful in the applications, where extract of one watermark should depend on the extract of other watermark. The embedding and extraction process uses multi-resolution analysis of wavelet Transform. In embedding process, multiple watermarks are embedded one after the others and the multiple watermarks are extracted from the watermarked images is the extraction process. The experimental results on different types of cover images, shows that the proposed method is robust to common image processing attacks.

Keywords: multiple watermarking, discrete wavelet transform, successive watermarking, robustness, PSNR.

1. Introduction

Digital Watermarking is an important technique in the area of information security. Many digital watermarking techniques have to solve this problem by hiding an invisible watermark in an image to prove the ownership of the image. Most watermarking algorithms supports one watermark embedding, but there are great restrictions when one watermarking algorithms are tried into practical applications in few rare situation, like when multiple users share the copyright, it is need to support multiple users to embed their watermarks synchronously. This highlights the need for multiple watermarking. To advocate several goals one might wish to embed multiple watermarks into the same image so as to achieve the robustness to large range of image processing operations and to improve the security level.

Multiple watermarking techniques in spatial and transform domain methods are discussed [1]. Embedding binary visualized image into the original image by modifying coefficients of wavelet domain in LL bands with appropriate strength factor in order to compromise between acceptable imperceptibility level and attacks resistance are presented [2]. Their method achieves robustness level of various attacks such as image processing and rotation attacks. An optimal wavelet based watermarking algorithm that embed a binary logo in all the four sub-bands of wavelet transform. Watermarks are embedded with variable scaling factor in different sub-bands. The scaling factor is high for the LL sub-band and it is low for other three sub-bands [3].

An integer wavelet based multiple logo-watermarking schemes for copyright protection of digital image is presented [4]. Their method shows better robustness to attacks. Multiple watermarking is used for embedding multiple watermarks into the host single image to provide authentication without bearing on the optical quality of the image [5]. A multiple robust digital watermarking system for still images is presented [6]. Their method shows the results is resistant to cyclic shifts, row and column removal, cropping, addition of noise and JPEG transforms. Tapas Bandyopadhay et al. [7] proposed the imperceptibility quality of the images is quite good after embedding the watermark and subsequent compression. Their method of watermarking is robust against common signal processing attacks and geometric attacks.

Mintzer et al. [8] discussed three types of watermarking applications in the context of multiple watermarking and identify different ways how to employ and to interpret multiple watermarking. Multiple watermarks can be used to address multiple applications or one application may be addressed several times. For example, a first watermark can be used to embed ownership information, a second one for integrity verification, and a third one for captioning. On the other hand, there can be multiple copyright watermarks, multiple verification watermarks, or multiple watermarks for multiple captions. Focusing on the way how single watermarking techniques are actually fused into multiple watermarking schemes, Sheppard et al. [9] distinguish three main categories of multiple watermarking techniques: The first category is composite watermarking. In this method all watermarks are combined into a single watermark which is subsequently embedded in one single embedding step. The second category is segmented watermarking. In this method the host data is partitioned into disjoint segments a priory and each watermark is embedded into its specific share. The third category is successive watermarking: Watermarks are embedded one after the other. This approach is also denoted Re-watermarking in literature. Shieh et al. [10] proposed a successive watermarking scheme where the first mark is embedded in a vector quantization domain whereas the second watermarking scheme operates in the middle DCT frequency band. This approach is suited in principle for their scenario, but it is restricted to two watermarks in the described setting and it is problematic in general due to the limited number of different watermarking domains available. The classical
robust watermarking techniques for multiple re-watermarking are discussed [11]. Their method focus on a comparison of the usefulness of blind and non-blind algorithms. Daniel Mark et al. [12] demonstrated that watermark interference in multiple re-watermarking applications can be limited better by using disjoint frequency bands for embedding the different marks as compared to simply using different embedding domains. Their method shows the watermarks are all embedded into the same frequency band for some reason it is preferable to use different embedding domains.

In this paper a digital image multiple successive watermarking scheme based on wavelet transform is proposed. In the proposed method, the PSNR and image quality are degraded with every new watermark embedded into image, and the watermarked images are tested for non-geometric attacks such as additive noise, median filtering and JPEG compression and common image processing attacks such as sharpening and smoothing.

This paper is organized as follows; The Proposed algorithms for watermark embedding and extraction process are explained in section 2. The experimental results and discussions are presented in section 3. Conclusion of the present work is given in section 4.

2. Proposed scheme

The proposed scheme is embedding of multiple watermarks by decomposing the original image using discrete wavelet transform

2.1 Discrete wavelet transforms

Wavelet analysis decomposes images into component waves of varying durations, called wavelets. These wavelets are localized vibrations of a sound signal, or localized variations of detail in an image. The heart of wavelet analysis is multi resolution analysis. Multi resolution analysis is the decomposition of an image into sub images of different size resolution levels. The digital image watermarking scheme that are base don Discrete Wavelet Transform (DWT) are becoming more interesting. Fig. 1 shows the set of original images 512×512 size of Lena, Water lily, Cameraman and Gold Hill as the gray scale images.

![Original Images](image1.png)

Fig. 1. Original Images (a) Lena (b) Water lily (c) Cameraman (d) Gold Hill

In two-dimensional discrete wavelet transform, each level of decomposition produces four frequency bands of data, one corresponding to the low pass band (LL), and three other corresponding to horizontal (HL), vertical (LH), and diagonal (HH) high pass bands. The decomposed image shows an approximation image in the lowest resolution low pass band, and three detail images in higher bands. The low pass band can further be decomposed to obtain another level of decomposition. In Fig. 2 shows the general wavelet decomposition of original image. The proposed method based on wavelet transform and the watermark is applied to approximation sub-band LL.

![General wavelet Decomposition of image](image2.png)

Fig. 2. General wavelet Decomposition of image

2.2 Multiple successive watermarking

Fig. 3 shows 48×48 size gray scale logo is used as watermark image, such as first watermark, second watermark and third watermark.

![Watermark Images](image3.png)

Fig. 3. (a) First watermark (b) Second watermark (c) Third watermark

The proposed method uses multiple successive watermarking technique for embedding and extraction. This method is to embed the watermarks one after the another, from the watermarked images the watermarks are extracted from one after the another. Fig. 4 shows the multiple successive watermarking by using three watermarks.

![Multiple successive watermarking](image4.png)

Fig. 4. Multiple successive watermarking
2.3 Watermarking Embedding Process

The watermark used for embedding is a gray scale image, which is small compared with the size of the original image. The block diagram of multiple successive watermarking of watermark embedding process is shown in Fig. 5. The steps for watermark embedding are briefly listed as follows,

1. The original image is decomposed by single level by using discrete wavelet transform
2. Watermark $W_1$ is converted into binary image ($b=0,1$) denoted as $b(W_1)$
3. To improve the security, the binary watermark $b(W_1)$ is converted by the following equation

$$sb(W_1) = \begin{cases} 1 & \text{iff} \quad b = 0 \\ 1 & \text{iff} \quad b = 1 \\ 0 & \text{iff} \quad b = \text{null} \end{cases}$$

(1)

4. The watermark $sb(W_1)$ is embedded into the gray scale original image in LL sub band, by the following equation

$$WI_1(i,j) = I(i,j) \times e^{(\alpha \times sb(W_1(i,j)))}$$

(2)

where, $WI_1 = $ Watermarked Image1 $sb(W_1) = $ First Watermark $I = $ Original Image and $\alpha = $ Scaling factor which determine the strength of watermark
5. The inverse wavelet transform is performed to get the watermarked image1
6. Similarly, the second and third watermarks are embedded into the watermarked images, to get the watermarked image2 and watermarked image3.

The performance of watermarking technique can be evaluated by peak signal to noise Ratio (PSNR). The PSNR is used to measure the quality of watermarked image, which is given by

$$PSNR(dB) = 10 \log_{10} \frac{255^2}{MSE}$$

(3)

2.4 Watermarking Extraction Process

The watermark extraction processes is reverse shown in Fig. 6. The steps for watermark extraction are briefly listed as follows,  

1. The watermarked image3 and the watermarked image2 decomposed by single level by using discrete wavelet transform
2. The watermark $sb(W_3)$ can be extracted from the watermarked image3 in LL sub band. Then it’s divided by the watermark strength factor $\alpha$ is given as follows,

$$e^{(\alpha \times sb(W_3(i,j)))} = WI_3(i,j) / WI_2(i,j)$$

(4)

$$\alpha \times sb(W_3(i,j)) = \log(WI_3(i,j) / WI_2(i,j))$$

(5)

$$sb(W_3(i,j)) = \frac{(\log(WI_3(i,j) / WI_2(i,j)))}{\alpha}$$

(6)

3. The watermark $b(W_3)$ can be obtained from $sb(W_3)$ by using the following equation

$$b(W_3) = \begin{cases} 0 & \text{iff} \quad sb = -1 \\ +1 & \text{iff} \quad sb = +1 \\ 0 & \text{iff} \quad sb = \text{null} \end{cases}$$

(7)
4. The second and first watermarks are extracted from the watermarked images and original image by repeating the above steps.
Normalized Correlation (NC) is used to measure the quality of watermark after extraction. The NC between the extracted watermark \( W'(i, j) \) and the embedded watermark \( W(i, j) \) is defined as

\[
NC = \frac{\sum_{i=1}^{H} \sum_{j=1}^{L} W(i, j) \times W'(i, j)}{\sqrt{\sum_{i=1}^{H} \sum_{j=1}^{L} [W(i, j)]^2}} \quad (8)
\]

### 3. Experimental results and discussion

In this paper, a robust multiple re-watermarking technique is proposed based on wavelet domain for gray scale images.

#### 3.1 Imperceptibility Evaluation

Table 1 shows the performance measures on four different watermarked images and extracted watermarks such as Lena, Water lily, Cameraman and Gold Hill images of PSNR and NC values.

#### 3.2 Robustness Evaluation

To prove the robustness of the proposed method non-geometric and common image processing attacks has been applied. The watermarked images are tested for non-geometric attacks such as additive noise, median filtering and JPEG compression. The watermarked images are tested for common image processing attacks such as sharpening and smoothing. Table 2 shows the results for non-geometric and common image processing attacks on Cameraman image. The watermarked images are corrupted with salt and pepper noise at the density of 5%. Table 2 fig. (a) shows the noise corrupted watermarked images of Camera Man and it is extracted watermarks. The watermarked images are added with Gaussian noise of variance 5%. Table 2 fig. (b) shows the noise added watermarked image of Camera Man and it is extracted watermarks. Median filtering is a nonlinear operation used in image processing to reduce noise in an image. Table 2 fig. (c) shows the watermarked images of Camera Man and it is extracted watermarks for 3 x 3 filter size. Sharpening operations are used to enhance the subjective quality. Table 2 fig. (d) shows the sharpening of watermarked images of Camera Man and it is extracted watermarks. Table 2 fig. (e) shows smoothing of watermarked images of Camera Man and it is extracted watermarks. Table 2 fig. (f) shows the extracted watermarks and image quality of watermarked images of Camera Man after attacking by JPEG compression with the Quality of 90.

### Table 1. PSNR and NC values for Watermarked Images and Extracted watermarks

<table>
<thead>
<tr>
<th>Images</th>
<th>PSNR(dB)</th>
<th>NC</th>
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<tbody>
<tr>
<td>Lena</td>
<td></td>
<td></td>
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<tr>
<td>Water lily</td>
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<td></td>
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<tr>
<td>Cameraman</td>
<td></td>
<td></td>
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<tr>
<td>Gold Hill</td>
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</tbody>
</table>

#### Table 2. PSNR and NC values for Non-geometric and common image processing attacks in Cameraman Image

<table>
<thead>
<tr>
<th>Attacks</th>
<th>W. Watermarked</th>
<th>E. Watermarked</th>
<th>PSNR(dB)</th>
<th>E. Watermarked</th>
<th>E. Watermarked</th>
<th>E. Watermarked</th>
<th>NC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt &amp; Pepper noise at a density of 5%</td>
<td>[Image]</td>
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<td>[Image]</td>
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<tr>
<td>Gaussian Noise of variance 5%</td>
<td>[Image]</td>
<td>[Image]</td>
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<td>[Image]</td>
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<td>[Image]</td>
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<tr>
<td>Noise filtering for 3 x 3 mask</td>
<td>[Image]</td>
<td>[Image]</td>
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<tr>
<td>Sharpening</td>
<td>[Image]</td>
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<tr>
<td>Smoothing</td>
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<tr>
<td>JPEG compression with Quality of 90</td>
<td>[Image]</td>
<td>[Image]</td>
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<td>[Image]</td>
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<td>[Image]</td>
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#### Table 3. Comparison to existing method

<table>
<thead>
<tr>
<th>Value</th>
<th>Existing method</th>
<th>Proposed method</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSNR(dB)</td>
<td>38</td>
<td>39.71</td>
</tr>
</tbody>
</table>
The proposed method shows higher PSNR value when compared to existing method for the final host (Lena) image. As a future initiative, to compare a composite and segmented watermarking.

4. CONCLUSION
In proposed method, the embedded multiple watermarks shows good imperceptibility on watermarked images and robustness on attacks, such as non-geometric attacks (additive noise, median filtering and JPEG compression) and the common image processing attacks (sharpening and smoothing).

REFERENCES