ENHANCED DIGITAL WATERMARKING ALGORITHM FOR DIRECTIONALLY SELECTIVE AND SHIFT INVARIANT ANALYSIS

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Abstract— *Based on the good characteristics of dual-tree complex wavelet transform (DT-CWT), an improved digital watermarking algorithm is proposed here. The algorithm improves the embedding scheme by selecting the embedding channels and using the visual masking of Human Visual System.This also uses the spread spectrum in embedding scheme and Error correction code, in order to increase the robustness against common attacks different filtering attack etc., This algorithm increases the performance of watermark and has better robustness against common attacks.*

Keywords: Spread spectrum, Error correction code

1.INTRODUCTION

WITH the fast growth development of computer network technique and multimedia technology, digital media(such as image, video, audio or text) are stored, transmitted and distributed through Internet without any loss in the quality of the content. Hence, some way of protection of copyrighted digital data is required. A digital watermarking technique has been developed to protect intellectual property from illegal duplication and manipulation. Digital watermarking means embedding information into digital media in such way that it is imperceptible to a human observer but easily detected by means of computing operations in order to make assertions about the data. The watermark is needed to be robust against intentional removal by malicious parties. Thus by means of watermarking, the data is still accessible but permanently marked [1], [2]. Watermarking schemes can be robust or fragile. Robust watermarks are designed to resist to malicious or intentional distortions, such as general image processing and geometric distortions [3]; while a fragile watermarks are required for the purpose of authentication and verification. We can also classify watermarking schemes according to operation domain: the spatial domain and frequency domain. The simplest watermarking technique embeds a watermark directly into the spatial domain by modifying the Least Significant Bit (LSB) plane of the original image [4]. The watermarking scheme based on the frequency domains can be further classified into the Discrete Cosine Transform (DCT) [5], Discrete Fourier Transform (DFT) [6], Discrete Wavelet Transform (DWT) [7], Dual tree complex wavelet transform (DT-CWT) and others. In general, the transform domain techniques have provided more advantages and better performances than those of spatial ones in most of digital watermarking development and researches. The standard discrete wavelet transform has been exploited with great success across the scope of signal and image processing applications. For example, the DWT has the following advantages, such as good energy packing, perfect reconstruction with short support filters, no redundancy and low computation complexity. However, it lacks shift invariance (i.e., which means that small shifts in the input signal can cause major variations in the distribution of energy between DWT coefficients at different scales), and suffers from poor directional selectivity for diagonal features, because the wavelet filters are separable and real. In order to overcome these problems, complex wavelets have been proposed. Kingsbury's dual-tree complex wavelet transform (DT-CWT) is an outstanding example [8], [9]. The dual-tree complex wavelet transform is a relatively new development to the discrete wavelet transform (DWT), with important additional properties [9]:

- Approximate shift invariance;
- Good directional selectivity in 2-dimensions (2-D) with Gabor like filters (also true for higher dimensionality, m-D);
- Perfect reconstruction using short linear-phase filters;
- Limited redundancy (2:1 in 1-D and 4:1 in 2-D);

• Low computation comparing to other shift invariant transformations.

The work discussed in this paper is concerned with the design of robust and semi-blind watermarking algorithms with complex wavelet transform. We choose to use the complex wavelet transform as our watermarking domain because it is a relatively new transform and has useful properties for image processing applications. Previous work shows that DT-CWT gives good performance in image watermarking. In [10], [11], [12], [13], [14], [15], [16]. The outline of this paper is as follows: in the next section, we present the different steps for the proposed scheme. In Section III, we present the experimental results, and finally the paper is ended by a conclusion in Section IV.

II. PROPOSED WATERMARKING ALGORITHM

The new watermarking method that we propose is based on dual-tree complex wavelet transform. The overview of our watermarking scheme is illustrated in Fig. 1. In this scheme, an input gray-scale image (512x512 pixels) is split into many non-overlapping small blocks with 8x8 pixels; the sub-image (256x256 pixels) is then constructed under control of secret key ”key1”. On the other hand, a watermark is encrypted and decomposed into different parts which are adaptively spread spectrum and embedded in corresponding highest sub-bands of the 3-level DT-CWT transformed original sub-image. One example of oriented sub-bands of 3-level DT-CWT decomposition of an image is presented on Fig. 2. This newly proposed scheme consists of four parts, including: image preprocess, watermark preprocess, watermark embedding, and watermark detection. Details are described in the following sections.

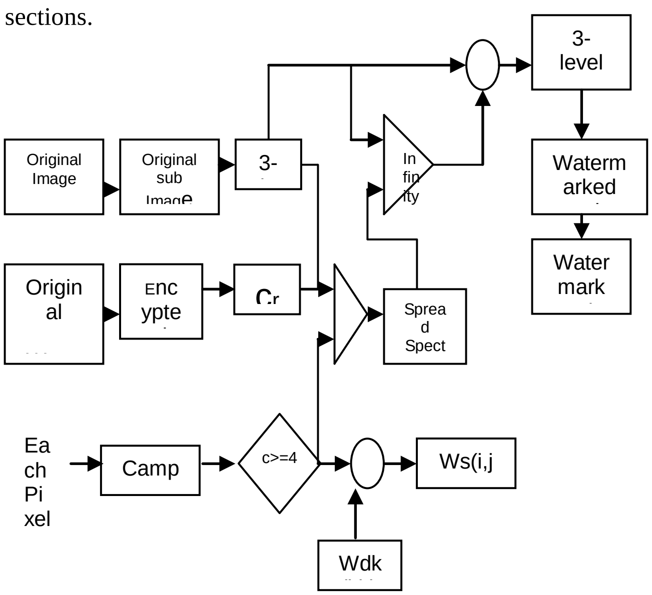

Fig. 1. Overview of the watermarking process.

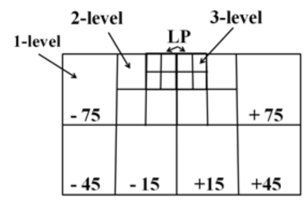

Fig. 2. 3-level DT-CWT decomposition of an image. LP corresponds to low-pass CWT coefficients.

A. Image preprocess

In our watermark scheme, we apply the dual-tree complex wavelet transform only locally, we transform the sub-image, which is extracted from the host image, in the complex waveletdomain by using 3-level DT-CWT. Modifying coefficients at levels coarser than 3 tends to be relatively ineffective and to introduce visual artifacts. To construct the sub-image, we use the following process [17]:

1) We first split the host image I_{orig}, into many nonoverlapping small blocks with 8x8 pixels in a scanline order. With the image has 512x512 pixels, we will get 4096 small blocks.

2) We label the small blocks from number 1 to number 4096, then we generate a sequence S_i, which contains 4096 elements, by using the logistic map under a special initial value ”Key1”. The logistic map is one of the simplest chaotic maps, described by:

$S_{k+1} = \mu S_k(1 - S_k)$; ($k$ = 0, 1, 2...); (1)

where $0 \leq \mu \leq 4$. When $3.5699456 \leq \mu \leq 4$, the map is in the chaotic state.

3) We multiply each element of S_i by 4096 and then round it toward infinity. Therefore, we obtain a new sequence S_n, in the integer domain [1, 4096].

4) We select the forefront 1024 different elements in the new sequence noted by S_1, and we choose the small blocks accordingly. Finally, we construct the sub-image in a scanline order. Fig. 3 visualizes an example of this selection process.

Fig. 3. Example of a constructed sub-image.

B. Watermark preprocess

In recent years, the chaotic data have been used for digital watermarking to increase the security. In our approach, a fast pseudo random number traversing method is used as the chaotic mechanism to change the watermark image W, which is a binary image $\{-1, 1\}$ with 93x62 pixels, into a pseudo random matrix W_d by using the Eq. 2. Then the W_d is divided into small images with size 31x31 pixels, and totally 6 independent sub-watermarks are obtained W_{dk} (Where k=1,2,...,6).

$$Key2 : W \Rightarrow W_d, W_d(Key2(i, j)) = W(i, j);\ i, j \in N; \quad (2)$$

”Key2” presents the second key in our watermark procedure, which is an exclusive key to recreate the watermark image.

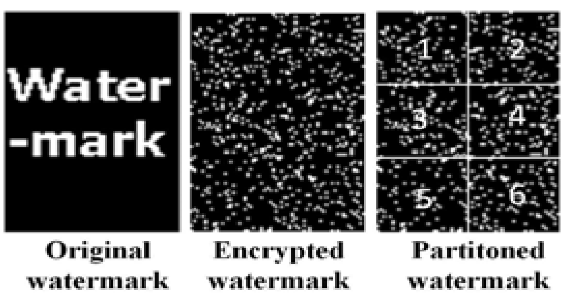

Fig. 4 shows an example of encrypted watermark image and the result of sub-watermarks.

C. Watermark embedding

Firstly, the original sub-image is decomposed by 3-level DT-CWT to obtain the 6 high-pass sub-bands. The DT-CWT coefficients are denoted by $\tilde{I}$. Secondly, With the Key ”Key3” the position of the 6 sub-watermarks is scrambled. Based on magnitudes of the 3-level DT-CWT high-pass coefficients, the sub-watermarks W_{dk} are adaptively spread spectrum. For each pixel (i,j,k) of each highest frequency sub-band in $\tilde{I}$, the value is compared with those of its eight neighbors, t denotes the total number which the value is larger than its eight neighbors, as described by the following formula:

W_s(i, j, k)=1, if ($t \geq 4$ and W_{dk} (i, j, k)=1)Or($t < 4$ and W_{dk} (i, j, k)= -1); -1, else.(3)

The resultant spread spectrum watermark W_s is stored (i.e., used in the extraction process) and embedded into the 6 highpass sub-band coefficients by using the following rule:

$$\hat{I}(i, j, k) = \tilde{I}(i, j, k) + \alpha * W_s(i, j, k) * |\tilde{I}(i, j, k)|; \quad (4)$$

where: k = 1, 2,..., 6.

- $\hat{I}$: are the watermarked real parts of the DT-CWT coefficients.
- $\tilde{I}$: are the original real parts of the DT-CWT coefficients.
- W_s: is the spread spectrum watermark sequence.
- α: is an intensity parameter of image watermark.

By the inverse DT-CWT, the watermarked sub-image is obtained. Finally, according to the label sequence S_1 (see sect. A), we put every small block of the watermarked sub-image into the original position of the host image. Thus, we get the watermarked image.

D. Watermark extracting

The extraction of watermark in image is an inverse process of embedding scheme. The watermark detection is accomplished without referring to the original image. Only the watermarked image, spread spectrum watermark W_s, and Keys (Key1, Key2, and Key3) need to be used. The watermark extraction algorithm can be summarized as follows:

1) The 3-level DT-CWT is performed on watermarked subimage, which is extracted from the watermarked image using ”Key1” (see sect. A). $\hat{I}$ denotes the DT-CWT coefficients.

2) Constructed the encrypted watermark image $\hat{W}_{dk}$: for each embed watermark pixel in $\hat{I}$, its value is compared with those of its eight neighbors; t denotes the total number which the value of the pixel in $\hat{I}$ is larger than its neighbors. Encrypted watermark image can be formed as:

$\hat{W}_{dk}$ (i, j, k)=1, if ($t \geq 4$ and W_s(i, j, k)=1)Or($t < 4$ and W_s(i, j, k)= -1); -1, else. (5)

3) Reconstructed watermark image $\hat{W}$: the 6 parts of the watermark $\hat{W}_{dk}$ are collected under control of secret key ”key3”, then the original large watermark image $\hat{W}$ can be reconstructed by using the inverse transform of the preprocessing with the secret key ”Key2”. This can be shown in Fig. 5, where the

original image, the watermarked image, the absolute difference between the original and the watermarked images, the 6 parts of spread spectrum watermark, the 6 parts of extracted encrypted watermark and the reconstructed watermarks with true and false keys. Moreover, if one secret key is changed, the final watermark can not still survive.'

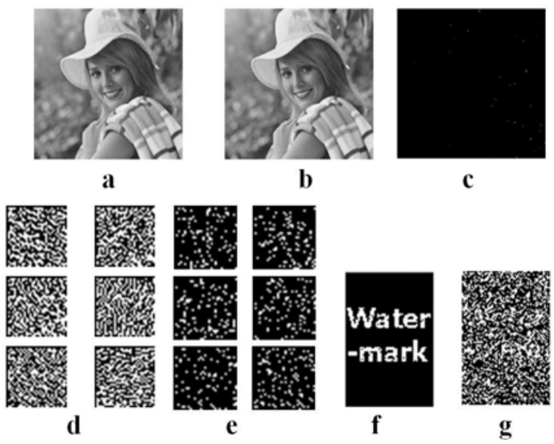

Fig. 5. An example of the mentioned watermark extracting procedure. (a) original image, (b) watermarked image, (c) absolute difference between the original image and the watermarked image, (d) the 6 parts of spread spectrum watermark, (e) the 6 parts of extracted encrypted watermark, and (f)-(g) the reconstructed watermarks with true and false keys, respectively.

IV. Conclusion

Proposed method describes robust and semi-blind digital image watermarking in frequency domain, which is computationally efficient. This method applies the Dual Tree Complex Wavelet Transform; the watermark image is encrypted and decomposed into different parts which are adaptively spread spectrum and added into the DT-CWT coefficients. The experimental results have confirmed that this new scheme has high fidelity and it is robust against JPEG compression, Scaling, Affine, Remove lines, PSNR attacks, and signal processing (Salt & pepper, Gaussian noise, and Median filter). The comparison of the proposed scheme [18] shows that our DTCWT approach is more effective.

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