

Digital Image Watermarking Algorithm Using Eigen Values and Singular Value Decomposition for Gray Level Images

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Abstract: - In the current globalized world, the right of ownership is at stake. This arises due to the easy exchange of data through various channels of communications and lack of authentication. The problem of piracy can be limited to a large extent by using a technique called Digital Watermarking.. The main aim of this paper is to increase robustness by implementing the digital watermarking using Singular Value Decomposition (SVD). In this paper, instead of using the conventional SVD, introduce a new algorithm to directly compute the largest eigenvalue and eigenvector of segmented image blocks. By using this approach, our proposed watermarking scheme has lower computational complexity than various SVD based schemes. Experimental results also showed that our watermarking scheme outperforms several widely used schemes in terms of robustness. Moreover, using the proposed algorithm, we designed a digital image watermarking using eigen values and improved Singular value decomposition for gray level images, where watermarked images can be verified without using the pre - defined watermark and a secret key..

Keywords: Eigen value, Eigen vector, SVD, watermarking.

I. INTRODUCTION

Digital watermarking is a technique that embeds secret information, such as identifiers, words, image logos and so on imperceptibly into multimedia data to prove data ownership. The special application of digital watermarking technique requires that the embedded watermark should be not only transparent to observers, but also robust enough so that it cannot be easily destroyed or removed after some digital image processing or attacks [1]. According to the practical application, the digital watermarking technologies can be classified into three types including image watermarking algorithm [1], image watermarking algorithm [2] audio and video watermarking algorithm [3][4]. More recent research have turned their attention to image watermarking algorithms and developed many methods including spatial domain method, frequency domain method, physiological model method and soon [5-7]. According to the watermark detection method whether needs original host image, image digital watermarking algorithms can be classified into non blind watermarking algorithm and blind watermarking algorithm [8-10]. Non blind watermarking technology refers to the detection method needs original host image, while blind watermarking algorithm means that the watermark extraction doesn't need original image. In the process of non blind watermark extraction, it is hard to find the original

image rapidly and accurately in the massive image database, so it affects the efficiency of watermark extraction. Therefore, blind watermarking algorithm has great research significance and practical value in the current research region of image digital watermark. In this paper, a blind watermark algorithm is developed to realize the digital copyright protection. Nowadays there are many existing watermarking algorithms based on image watermarks [11]. Some methods embed the watermark information through changing the relative relationships of pixel values in spatial domain or the coefficient values of frequency domain. In fact, the visual masking effect is also an important evaluation index of watermarking algorithm. Many algorithms only pay attention to specific watermark information hiding method, while ignoring the position of information hiding. According to Human Visual System (HVS), embedding information in texture areas with high visual masking effect, can not only realize the watermark information hiding, but also can improve the robustness of information hiding. In the authors present a watermarking approach which embeds the singular values (SVs) of the original image into the watermark to attain the lossless objective. The scheme degrades the quality of the embedded watermark image by replacing SVs of the watermark image with those of the original one to some acceptable degree in advance [1].

II. IMAGE WATERMARKING

A Singular Value Decomposition

Singular Value Decomposition (SVD) is one of the most powerful numeric analysis techniques and its application in image compression and image watermarking field is also compelling.

Let A be a grayscale image with size of $m \times n$. Every real matrix A can be decomposed into three matrices as

$$A=USV^T$$

by SVD, where U and V are orthogonal matrices with size of $m \times m$ and $n \times n$ respectively, S is a matrices with size of $m \times m$ and $n \times n$ respectively, S is a diagonal matrix with the same size as A and with larger singular value entries in decreasing order.

B Watermark Preprocessing

Most existing digital watermarking methods concentrated on the embedding methods of binary image as the watermark. Along with the development of multimedia and digital watermarking technique, more and more gray-level image watermark algorithms are needed because the gray-level image can take more information. In this paper we improve the method described in [1] and embed the watermark into the host image. The detail of the method is as follows.

Step 1: Perform SVD on the watermark image and extract the first 20 values of matrix S which are called eigenvalues in this paper [1].

Step 2: For every eigen value marked as $X_i(1 \leq i \leq 20)$, firstly we use the floor(X) function to get the greatest integers less than or equal to X, and then we convert every decimal bit of X_i into binary number[1].For example, if the eigen value X_i is '3579', the result will be '0011 0101 0111 1001' after the operation of step 2.

Step 3: Because most eigenvalues are no more than 10000, we make a length limitation of the encoded eigenvalue to 16 bits. If there are some encoded strings more than 16 bits, from left to right, we mark the first bits which are not belong to the 16 bits as W_{high} , the length of W_{high} is recorded as N, and then the first N bits of the encoded minimal eigenvalue is replaced by W_{high} . The W_{high} and the original code are separated by the string of '1111' which is not equal to any decimal bit from 0 to 9[1].

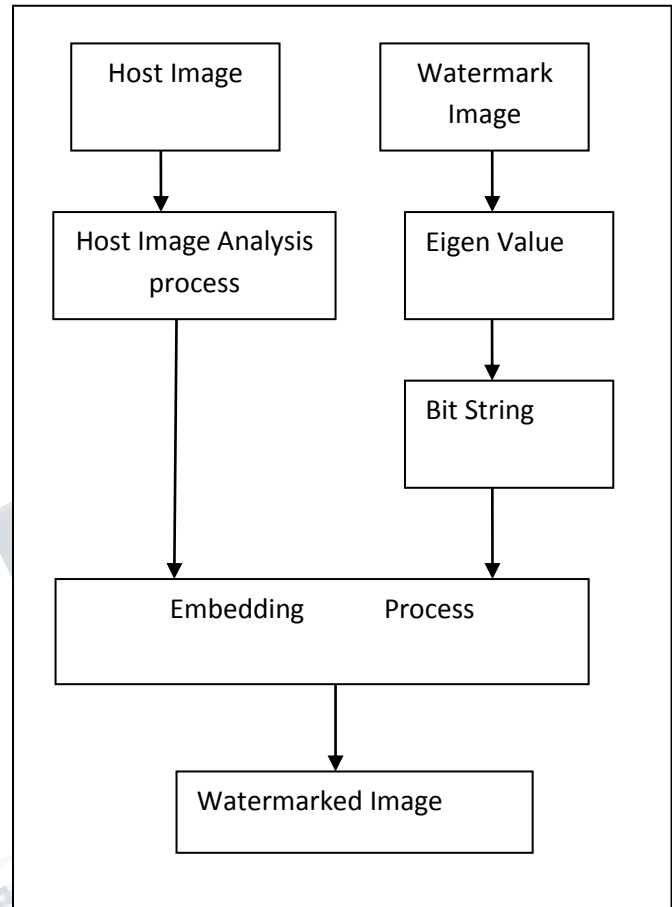


Figure 1 Watermark Embedding

For example, if there is an eigenvalue '25379' and its bit string is '0010 0101 0011 0111 1001', a minimal eigenvalue '24' and its bit string is '0000 0000 0010 0100', after Step 3, W_{high} is marked as '0010', the two eigenvalues are marked as '0101 0011 0111 1001' and '0010 1111 0001 0100' separately.

Step 4: Horizontally concatenates the corresponding binary bit string according to the descending order of the 20 eigenvalues and save as $W_{encoded}$ which will be embedded into the host image as secret information [1].

C Host Image Processing

Based on human visual system's characteristic, the human eyes have different sensitivity to noise in areas with different luminance and texture. So we analyze the host image before watermark embedding to ensure the

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imperceptibility of the proposed watermarking scheme. In this paper we adopt the SVV (Singular Value and Variance) method to analyze the host image. The method is described as follows:

Step 1: Divide the host image into 8×8 sub-blocks in Spatial domain.

Step 2: Compute each sub-block's variance V1 and find the maximum value V_max among them. Define the normalized variance as $A1 = V1/V_max$.

Step 3: Perform singular value decomposition (SVD) on each sub-block and then computer E of the obtained S matrix.

$$[U \ S \ V] = \text{svd}(A), \ E = S(1,1) / S(2,2)$$

Where a stands for the matrix of the sub-block, svd denotes the operation of SVD, U, S and V are the three result components of SVD transformation. S(1,1) and S(2,2) denote the two maximum values in the diagonal matrix S.

Step 4: Find the maximum value of E marked as E_max and define the normalized E as $A2 = E / E_max$.

Step 5: Calculate activity factor AF of each sub-block as

$$AF = \alpha 1 \times A1 + \alpha 2 \times A2$$

where $\alpha 1$ and $\alpha 2$ are the weights of A1 and A2 with $\alpha 1 + \alpha 2 = 1$.

Step 6: Sort all the sub-blocks' activity factors in decreasing order. The sub-blocks which have large magnitude of activity factors have complex texture and median luminance and are suitable for embedding watermark with imperceptibility.

After analyzing the host image using our method, we have obtained the activity factors of all the sub-blocks. The high magnitude of activity factor means the corresponding sub-block is not only suitable for embedding watermark but also robust to the attacks. So we select the best sub-blocks Which have large values of activity factors and good visual masking effect to embed watermark.

III. WATERMARKING ALGORITHM

A Embedding Algorithm

In this sub-section, we employ singular value decomposition to embed watermark into the selected subblocks of host image after the preprocessing of the SVV method. Our algorithm is robust because the maximum SV is stable to the

attacks that always encountered in digital image processing. SVD_based algorithm is described as follows:

Step 1: Perform SVD on each selected 8×8 sub-block.

Step 2: Choose the maximum SV marked as S(1, 1) in the diagonal matrix S.

Step 3: Use dither modulation method to insert one bit Watermark signal into each sub-block according to this Formula

$$L = \text{fix}(S(1,1), Q)$$

$$\text{If } W_encoded(i) = 1 \quad S(1,1) = L \times Q$$

$$\text{else } W_encoded(i) = 0 \quad S(1,1) = L \times Q / 2$$

Where L denotes the integer part of the result of $S(1, 1)/Q$, W_encoded denotes the watermark bit and Q denotes the quantization step.

Step 4: Perform the inverse SVD on each sub-block to get the modified sub-image.

Step 5: Embed the watermarked sub-image back into the original host image.

B Extraction Algorithm

Watermark extraction algorithm is the exact inverse process of embedding algorithm. Watermark could be extracted without the original host image as soon as we get the secret keys.

Step 1: The value of extracted bit for a given sub-block is calculated according to this Formula

$$Z = \text{mod}(S^*(1,1), Q)$$

$$\text{if } (Z - Q / 2) < Q / 4 \quad W_recover(i) = 0$$

$$\text{Else} \quad W_recover(i) = 1$$

where Z stands for the modulus after division of $S^*(1, 1)$ and Q, Q is transmitted as secret key.

Step 2: Decode the obtained W_recover according to the inverse order of coding and record the result as W_Decoded. W_Decoded denotes the eigenvalues of the watermark.

Step 3: Use inverse process to regain the hidden watermark.

IV. RESULT ANALYSIS

Figure 2 and Figure 3 are the result images of test images ‘Barbara’ and ‘Baboon’ of size 512×512. Figure 4 and Figure 5 show the original gray-level watermark of size 64×64 , 128×128. Taking ‘Baboon’ image for example, in the experiment we first calculate each sub-block’s activity factor according to the image’s texture and gray information. The watermarks as shown in Figure 4(a) and Figure 5(a) are respectively embedded into the selected sub-blocks using our algorithm. In the process of embedding, the weights value of α_1 and α_2 used in the experiments are set to 0.1 and 0.9 respectively, and the quantization step used is set to 55.

The PSNR (peak signal-to-noise ratio) is used in this paper to access the imperfectability of our algorithm, as Follows:

$$PSNR = \log_{10} \frac{255 * 255}{\frac{1}{H * W} \sum_{x=0}^{H-1} \sum_{y=0}^{W-1} [f(x, y) - g(x, y)]^2}$$

where $I(i, j)$ denotes the gray value of host image pixel, $I^*(i, j)$ denotes the gray value of watermarked image pixel, M and N are the height and width of host image. Because of the encoding processing for the watermarks of the proposed algorithm, the sizes of the watermarks are independent on our embedding scheme. Table 1 shows the PSNR results of different watermarked host images which have hidden different sizes of watermarks. All the results of PSNR are capable to insure the fidelity of the watermarked host images.



Figure 2. (a) Original host image ‘Barbara’. (b) Watermarked image

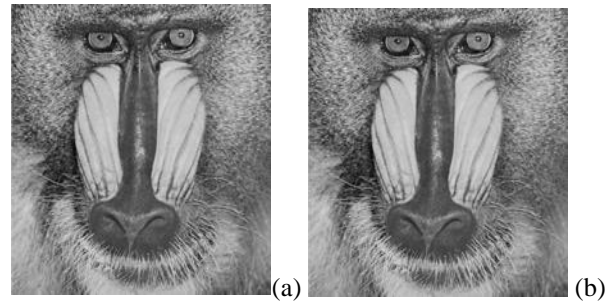


Figure 3. (a) Original host image ‘Baboon’. (b) Watermarked image

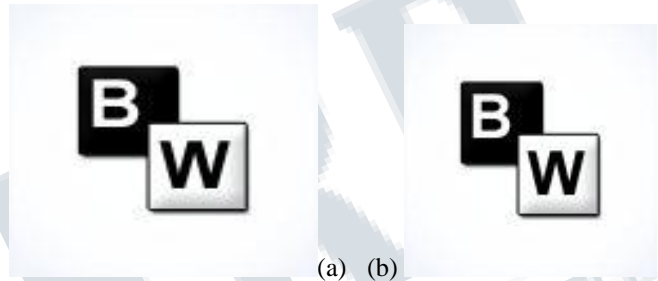


Figure 4. (a) Original watermark ‘Logo’ of size 64×64. (b) Watermark extracted from Figure 3(b) after watermark recovery

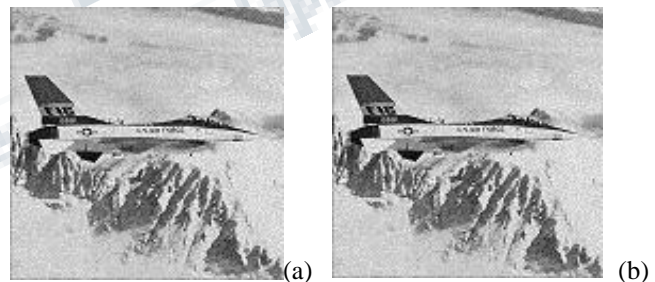


Figure 5. (a) Original watermark ‘Airplane’ of size 128×128. (b) Watermark extracted from Figure 3(b) after watermark recovery

TABLE 1.
THE PSNR OF DIFFERENT WATERMARKED HOST IMAGES FREE OF ANY ATTACKS

Host image \ Watermark	Barbara	Baboon
Logo 64×64	47.86	45.34
Air Plane 128×128	47.37	45.89

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In the watermark recovery sub-section, the extraction results are first decoded into the regained eigenvalues of the watermark. Figure 4 (b) and Figure 5 (b) show the result original watermarks that recognized. In the experiment, the eigenvalues of 20 gray-level watermark images are extracted and trained in the proposed Algorithm.

TABLE 2.
**THE RESULT OF WATERMARK RECOVERY AFTER
JPEG 30% ATTACK**

After JPEG 30% attack	Barbara	Baboon
Watermark total number	20	20
Right recognized number	20	19
Wrong recognized number	0	1
Precision	100%	95%

Table 1 and Table 2 shows the watermark recovery results after different attacks, where 'JPEG 30%' means JPEG compression with quality factor of 30% , The precision for different attacks indicates that the proposed algorithm is robust and the watermark recovery for gray-level watermark images is flexible and applicable.

V CONCLUSION

In this paper, a novel technique of digital image watermarking has been discussed. Our method is a new algorithm that employs the SVD to encode the gray-level watermark and extract watermark. We have utilized the characteristics of singular values and variance to preprocess the host image and then embed the watermark into the selected sub-blocks. Results demonstrate the excellent performance on both robustness and transparency of our scheme.

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