Realization and Simulation of Watermarking Algorithm Based on Spread Spectrum and DFT

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Abstract. In order to protect image copyright and anti-counterfeit authentication, digital watermarking technology arises at the historic moment. The contradiction between robustness and invisibility affects the development of watermarking technology. To solve this problem, a watermarking algorithm based on spread spectrum and DFT is proposed. The main work of this paper is as follows: firstly, image embedding watermarking: the original image is segmented into two-dimensional discrete Fourier transform, then the watermark information through sequence even spread spectrum is superimposed, and finally the image with watermark is obtained by the inverse discrete Fourier transform. Secondly, extracting watermark information: the discrete Fourier transform is applied to the blocks of the original image and the image with watermark, the spread spectrum watermark information is extracted by comparing the amplitude and the original watermark is obtained by the final solution and expansion. Finally, the simulation results show that the proposed algorithm has good performance in robustness and invisibility.

Keywords: DFT · Spread spectrum · Sequence pairs · Digital image watermarking

1 Introduction

1.1 Introduction to Digital Image Watermarking

Digital watermarking was formally proposed by Trikel et al. in the paper of "Electronic Watermark" in 1990s [1]. In this paper, a digital watermarking method based on least significant bit is proposed, but its anti-attack ability is weak and its robustness is not satisfactory. Since then, digital watermarking technology began to develop rapidly.

Digital image watermarking technology is usually divided into two categories: embedding watermarking into carrier space domain [2] and embedding watermarking into image transform domain. The spatial domain algorithm includes least significant bit algorithm (LSB) [3] and Patchwork algorithm [4]. The advantages of spatial domain algorithm are direct and simple, but its anti-attack performance is poor.

The frequency-domain transforms commonly used in change domain algorithms include DFT (discrete Fourier transform), DCT (discrete cosine transform) and DWT (discrete wavelet transform). Cox et al. proposed a digital watermarking scheme based

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on spread spectrum communication technology, embedding the watermark into the DCT region of the image [5], after which DCT domain algorithm developed rapidly. Uraniid et al. proposed a digital watermarking algorithm based on discrete Fourier transform. However, its computational complexity is high and its application value is not high [6]. Saini L K et al. proposed a combination algorithm based on DWT-DCT and verified the algorithm through common attacks [7]. At present, deep learning networks are also used to study image watermarking. For example, Zhou et al. proposed a robust watermarking scheme based on geometric correction codes, which improved the robustness of watermarking against common geometric transformation attacks [8].

1.2 Introduction to Spread Spectrum Communication

Spread spectrum communication is characterized by the bandwidth used for transmitting information is much larger than the bandwidth of the information itself. The basic idea and theoretical basis is to use the bandwidth transmission technology in exchange for the benefits of SNR.

In communication system, there will be various interference, which can be reduced or eliminated by using spread spectrum sequence. Sequence studies have been going on, but the results have not been significant. The concept of sequence pairs is derived from sequence analogy. In the spread spectrum communication system, the spread spectrum sequence of the transmitting end and the unspread sequence of the receiving end are not necessarily the same sequence, as long as the two sequences (called sequence couple) meet certain conditions can meet the engineering requirements for the best signal, which is the difference between sequence couple spread spectrum system and other systems. Thus, the concept of sequence pairs is introduced: suppose X and Y are two one-dimensional sequences of length N, then X and Y are said to form a sequence pair of N length, denoted as (X,Y); If the values of the elements of sequence X and Y are plus or minus 1, the sequence pairs (X,Y) are called binary sequence pairs.

When sequence pairs, Gold sequence [9] and m sequence [10] are used as spread spectrum sequences, the former has worse bit error rate performance than the latter two, but it can exist in any length, which makes up for the limitation that Gold and m sequences can only exist in some fixed length. It is found in the experiment that the bit error rate performance of the system may be better than that of Gold sequence and m sequence when there is a large sinusoidal interference in the system if the proper sequence pair is selected. Based on the above analysis, this paper adopts sequence pairs to spread spectrum processing of watermark information.

2 Realization and Simulation of Watermarking Algorithm Based on Spread Spectrum and DFT

2.1 Watermark Embedding Algorithm

Firstly, the original carrier image is divided into 8*8 data blocks, and then two-dimensional discrete Fourier transform is performed on each data block. Next, sequence pairs are generated and the original watermark information is repeated 61 times bit-by-bit, that is, the length of sequence pairs used in this paper. Then spread spectrum processing is carried out to generate a new spread spectrum sequence code. After all the above work is completed, the generated spread spectrum sequence code is superimposed with the amplitude spectrum of the carrier image after sub-block segmentation and DFT transformation, which is equivalent to successfully loading the watermark information after expansion into the original carrier image. After successful embedding, the image with watermark information can be obtained by inverse discrete Fourier transform. The block diagram of watermark embedding principle is shown in Fig. 1.

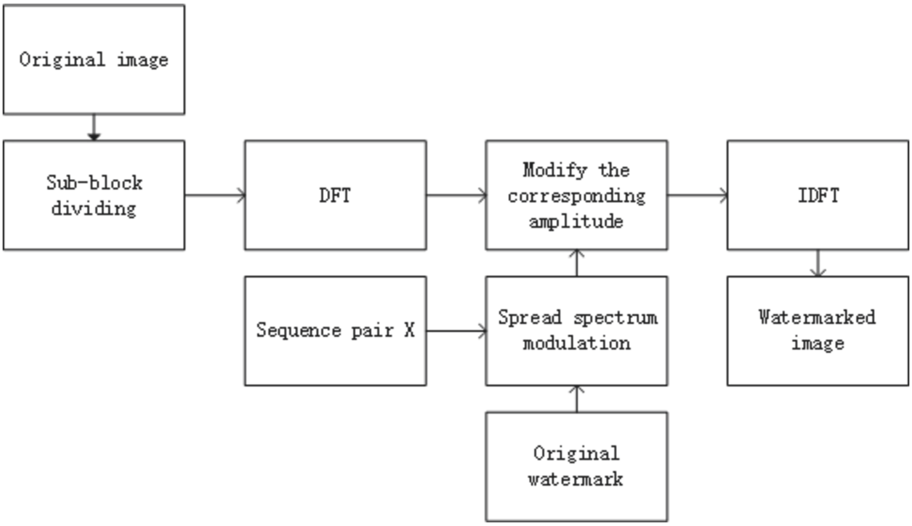

Fig. 1. Watermark embedding algorithm flow

2.2 Watermarking Extraction Algorithm

This algorithm uses the steps similar to the embedding algorithm mentioned above. It divides the carrier image that already contains watermark information into sub-blocks, and then makes DFT changes to each sub-block. After that, it compares the amplitude with the original carrier image that has also undergone segmentation and DFT transformation, so as to extract the spread spectrum watermark information effectively. After the steps are completed, sequence pair Y is used to de-expand the extracted spread spectrum information, that is, the spread spectrum watermarking information is multiplied bit by bit with sequence even Y within the length of a sequence even code element, then the sequence is added in the code cycle and compared with the decision threshold. Due to the sequence pairs have negative correlation, so if the comparison result is greater than 0, judgment is 0; If the comparison result is less than 0, judgment is 1. Finally, the original watermark information is obtained. The block diagram of watermark extraction principle is shown in Fig. 2.

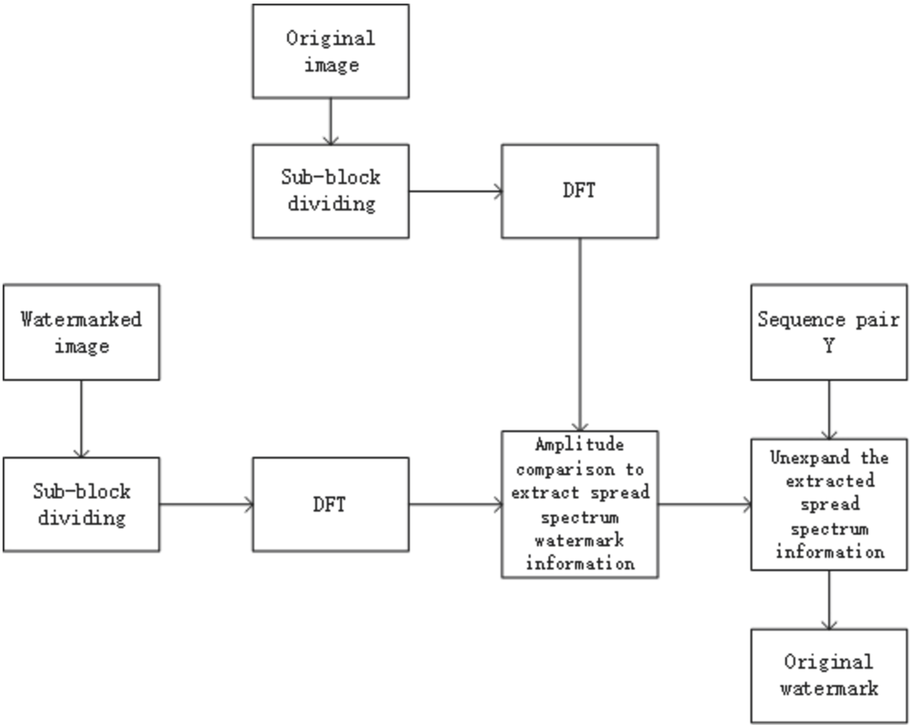

Fig. 2. Watermark extraction algorithm flow

3 Simulation Results and Analysis

In this paper, WIN10 and MATLAB R2016a are used as the experimental simulation environment, and the image size is 512 * 512 pixels. Figure 3 is the original image. Figure 4 shows watermark images. Figure 5 shows the watermark information obtained after sequential even spread spectrum.

Fig. 3. Original image

Fig. 4. (a) Original image 128 *1 28 pixels watermark image, (b) 64 * 64 pixels watermark image

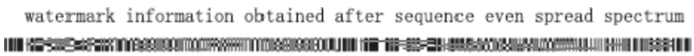

Fig. 5. 64 * 64 pixels watermark image watermark information after sequence even spread spectrum

In this paper, the Normalized Coefficient (NC) and Peak Signal to Noise Ratio (PSNR) are selected to evaluate the algorithm performance. NC is used to evaluate the similarity between the original watermark image and the extracted watermark image, and its value ranges from 0 to 1 [11]. The larger the NC is, the stronger the robustness of the algorithm is. PSNR is used to evaluate the distortion degree between the watermark carrier image and the original image, and its value ranges from 0 to 100 [12]. The larger the PSNR is, the better the visibility of the algorithm is.

Change the embedding strength K to 0.015, 0.02, 0.025 and 0.03 respectively, run the program, calculate the value of PSNR and NC. The experimental comparison results are as follows (Figs. 6, 7, 8, and 9).

1. When k = 0.015, the result is shown as follows, and get the PSNR = 93.522, NC = 0.98013.

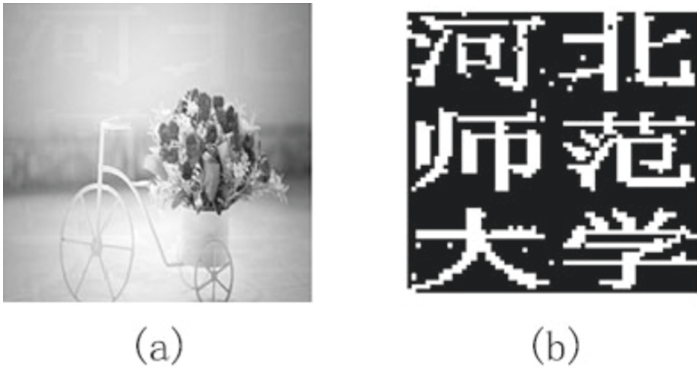

Fig. 6. (a) Carrier image with watermark, (b) Extract the watermark image

2. When k = 0.02, the result is shown as follows, and get the PSNR = 87.671, NC = 0.98279.

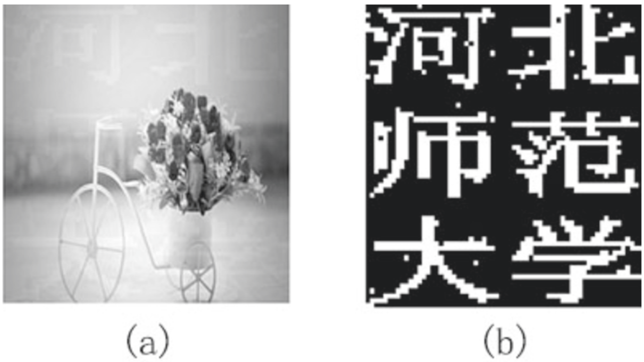

Fig. 7. (a) Carrier image with watermark, (b) Extract the watermark image

3. When k = 0.025, the result is shown as follows, and get the PSNR = 83.119, NC = 0.98281.

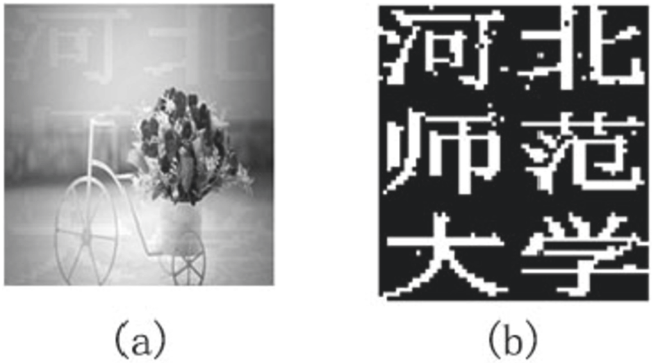

Fig. 8. (a) Carrier image with watermark, (b) Extract the watermark image

4. When k = 0.03, the result is shown as follows, and get the PSNR = 79.385, NC = 0.98409.

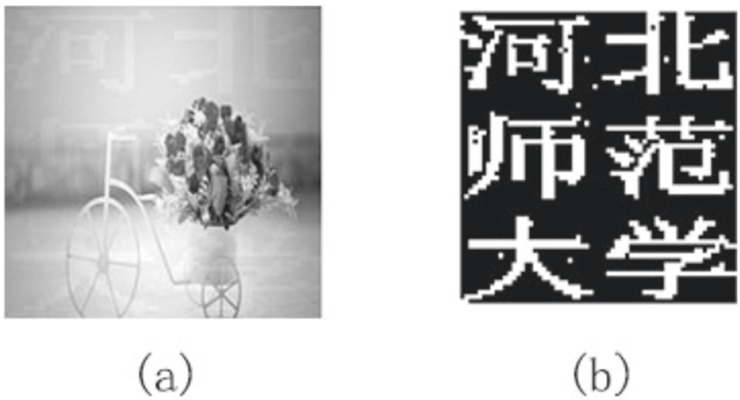

Fig. 9. (a) Carrier image with watermark, (b) Extract the watermark image

According to the above experimental results, with the increase of K, PSNR gradually decreases and NC gradually increases, which proves that there is a contradiction between watermark visibility and robustness. The values of NC are all above 0.98 and have good robustness.

4 Conclusion

In this paper, a watermarking scheme based on spread spectrum and DFT is proposed. Sequence pairs are selected to spread spectrum the watermarking information, and the useful watermarking information is extracted by using the excellent autocorrelation characteristics of sequence pairs, which is superposed in the image transform domain. The simulation results show that the robustness of the algorithm has achieved good results, and the robustness and invisibility of the algorithm will be further studied.

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