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DIGITAL IMAGE WATERMARKING ALGORITHMS BASED ON DUAL TRANSFORM DOMAIN AND SELF-RECOVERY

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Abstract- In view of dual watermarking algorithm for dual two value image watermarking, the watermark information there is a gray image watermarking in the expression is obviously insufficient. The proposed embedded in the carrier image on the dual watermark includes a two watermark image and a gray image watermarking algorithm, the persuasive power while maintaining the original two values of the watermark robustness at the same time, improve the watermark information. In order to balance the robustness and invisibility of watermarking algorithm, this paper analyzes the embedding position and strategy of transform domain algorithms, the DC coefficient in the carrier image is divided into blocks of DCT spectrum and spectrum on the combination of DWT coefficient method and the advantage of embedded dual watermarking, and use the NEC characteristic of the algorithm is improved adaptive based on the embedded mode. The gray image watermark bit plane decomposition compression high four bit plane information as watermarking, in reducing the original watermark loading and enhance the overall strength of self recovery system. This paper from the working principle, classification of digital watermarking, attack types, performance index, evaluation method and uses six aspects were introduced to the digital watermarking technology. Simulation study of a digital image watermarking algorithm based on DCT transform and Arnold transform, the algorithm's imperceptibility, robustness and security are analyzed, the algorithm for embedding process.

Index terms: Stay cable; positive pressure arch effect; mechanism; friction coefficient; ANSYS; contact analysis.

I. INTRODUCTION

Digital watermarking technology as an important branch of information hiding technology research field, since it has been paid attention to by many domestic and foreign experts and scholars and business groups, and gradually become a research hotspot in the field of information security [1]. In the development of Internet today, research on digital watermarking technology for copyright protection has great practical significance. In digital image watermarking algorithm as an example, if we can study with good visual effect, image watermarking algorithm robust, will be of great practical value in the copyright protection of digital image, if we can further develop into copyright protection products, will have a very broad commercial value [2]. For questions on how to copyright protection technology, digital watermarking technologies have emerged as information hiding technology research branch is one of the effective means of digital products copyright disputes.

The basic principles of digital watermarking technology means that the digital watermark information has a certain significance in the premise does not affect the value of the embedded covertly through a different approach to digital data processing work to become part of the work can not be separated from the carrier. The earliest watermarking algorithm for digital image watermarking is proposed to study the field published by Schyndel and Tirkel in 1994 in document [3-6] LSB algorithm based on spatial domain. The algorithm has good invisibility, realize the information capacity has the advantages of simple process and high quality. The watermark, but can not guarantee the robustness of the watermark information. In [7] Bender, this is called a "patchwork" (Patchwork) digital image watermarking algorithm based on spatial domain, this algorithm and the LSB algorithm has good invisibility, and is robust to common image processing attacks, but the amount of information less watermark in this algorithm, a far cry from the the actual application [8, 9].

In view of the dual watermarking algorithm at present the most extended based on the multiple functionality, they do not use dual watermarking good performance advantages to enhance the robustness of the watermarking algorithm [10]. In addition, the double watermark algorithm is chosen most of the two value image as the watermark embedding, although they have dual two the robustness of watermarking value advantage, however, is that few of watermark information, the protection of intellectual property is far better than the gray level watermark persuasive [11]. Therefore, this paper combines the actual situation has conducted the thorough research to the digital watermarking technology as well as the existing double digital watermark algorithm, and expatiates the dual watermarking self recovery technology, finally make a further improvement to the dual watermarking algorithm, proposed one kind based on the transform domain and self dual watermarking algorithm recovery technology [12-15].

Due to the digital image watermarking algorithm based on transform domain can be embedded watermark to the carrier image spatial energy distribution of all pixels, so that the watermark to obtain a stronger anti attack ability, so the image watermarking algorithm based on transform domain has great research value and practicability. At present, most research on digital image watermarking algorithm work is based on the transform domain, transform domain classical DCT domain, DFT domain and DWT domain, Koch [16] takes the lead in a digital image watermarking algorithm based on DCT domain, the watermarking information is embedded into the middle frequency DCT coefficients are selected, because the JPEG image compression is used to achieve the DCT, thus the algorithm has robustness against JPEG compression.

This paper from the working principle, classification of digital watermarking, attack types, performance index, evaluation method and uses six aspects were introduced to the digital watermarking technology. Simulation study of a digital image watermarking algorithm based on DCT transform and Arnold transform, the algorithm's imperceptibility, robustness and security are analyzed, the algorithm for embedding process. A digital image watermarking algorithm, and realizes the simulation, performance test work on the improved algorithm. Simulation study of a digital image watermarking algorithm based on DCT transform and DWT transform, as well as to the performance of this algorithm are analyzed, and then refer to the basic idea of the algorithm is proposed which combines the DCT transform and DWT transform, a new digital image algorithm, the new algorithm and the simulation for implementation, performance test

II. DIGITAL WATERMARKING OVERVIEW

2.1The working principle of digital watermarking

The watermark embedding operation is actually the image content information change, there are addition and multiplication of two main kinds of commonly used modification rule:

Additive criteria:

$$I_w(x,y) = I(x,y) + k \times W(x,y) \tag{1}$$

Multiplication rule:

$$I_w(x, y) = I(x, y) \times (1 + k \times W(x, y)) \tag{2}$$

Among them, I (x, y) on behalf of the carrier image, I (x, y) on behalf of the watermarked image, the w(x, y) represents the watermark embedding strength factor, said k.

Extraction of digital image watermarking, also need first to the carrier image, then under the control of the secret key, the watermark extraction algorithm to extract the watermark information is embedded procedure from extraction from the region [17].

2.2 Classification of digital watermarking

(1) According to the classification of digital watermark carrier type embedded in the digital products in different types of course belong to different types. Digital products including image, video, audio text, corresponding watermark video watermarking, digital watermarking, digital watermarking [18-19].

(2) According to the watermarking are classified according to the form of form after watermark embedding operation, whether can be the human recognition, digital watermarking can be divided into visible watermarking and invisible watermarking. In real life, shading examples visible digital watermarking is the most common is to add "confidential" words in the word document, the visible watermarking is equivalent to a statement. Without visible digital watermarking is required in the visual perception can not be aware of its existence, it is normally hidden embedded into the carrier, when the need to be extracted from the carrier. Unless there is a special statement, the object of study of digital image watermarking is invisible watermark.

(3) According to whether the watermark extraction need the original carrier classification in some watermarking algorithm, the watermark extraction operations need the original carrier participation, otherwise unable to watermark information is extracted, the watermarking algorithm is called non blind watermarking algorithm. Because the original carrier participation, usually non blind robust watermarking is better than blind watermark.

(4) According to the watermark information is valid according to the classification of watermark whether it contains valid information, digital watermarking can be divided into meaningful watermark and unmeaning watermark two. Meaningful watermark is refers to the watermark itself contains specific information effectively, such as the two value watermark image, gray image, the time and place or product serial number.

2.3Digital watermarking algorithm evaluation
2.3.1Robustness evaluation

At present, most of the visual processing quality information in the measurement methods are difference metric method, which is based on image pixel brightness values, which belongs to the quantitative measurement method, the evaluation results obtained using this method does not rely on subjective judgments, so it can compare the performance of various digital image watermarking algorithm is fair. Table 1 lists the difference metric commonly used method, which is based on the original image and the distorted image difference on, among them, Im,n said the original image pixel brightness values, I'm, n denote brightness distortion image pixel value.

Table 1. Differential metric methods commonly used

Maximum difference	$MD = \max_{m,n} \lvert I_{m,n} - I'_{m,n} \rvert$
Mean absolute difference	$AD = \frac{1}{M \times N} \sum_{m,n} \lvert I_{m,n} - I'_{m,n} \rvert$
Normalizati-on mean absolute difference	$NAD = \sum_{m,n} \lvert I_{m,n} - I'_{m,n} \rvert / \sum_{m,n} \lvert I_{m,n} \rvert$
Mean square difference	$MSE = \frac{1}{M \times N} \sum_{m,n} (I_{m,n} - I'_{m,n})^2$
Normalizati-on mean square difference	$NMSE = \sum_{m,n} (I_{m,n} - I'_{m,n})^2 / \sum_{m,n} I_{m,n}^2$
LP standard	$LP = \left(\frac{1}{M \times N} \sum_{m,n} \lvert I_{m,n} - I'_{m,n} \rvert^p \right)^{1/p}$
Laplace mean square difference	$LMSE = \sum_{m,n} (\Delta^2 I_{m,n} - \Delta^2 I'_{m,n})^2 / \sum_{m,n} (\Delta^2 I_{m,n})^2$ $\Delta^2 I_{m,\mathrm{n}} = I_{m+1,n} + I_{m-1,n} + I_{m,n+1} + I_{m,n-1} - 4I_{m,n}$
Signal to noise ratio	$SNR = \sum I_{m,n}^2 / \sum (I_{m,n} - I'_{m,n})^2$

The two images of the same as S x S the size of the gray value ratio formula between the image peak signal to noise:

$$PSNR = 10 \log_{10} \left(\frac{255^2}{MSE} \right) \tag{3}$$

In it:

$$MSE = \frac{1}{S \times S} \sum_{i=1}^{S} \sum_{j=1}^{S} \left[I'(i,j) - I(i,j) \right]^2 \tag{4}$$

MSE is the variance of the two. I(i, j) in the formula of said pixel values of the image carrier, I'(i, j) said pixel values of the watermarked image. The calculation formula of the normalized correlation coefficient between two images:

$$NC(W, W^*) = \frac{\sum_{i=1}^{P} \sum_{j=1}^{P} W(i,j) W^*(i,j)}{\sqrt{\sum_{i=1}^{P} \sum_{j=1}^{P} [W(i,j)]^2} \times \sqrt{\sum_{i=1}^{P} \sum_{j=1}^{P} [W^*(i,j)]^2}} \tag{5}$$

Where W (i, j) is the original watermark image pixel value of the pixel, W* (i, j) by extracting the watermark image is value.

2.3.2 Imperceptibility evaluation

Usually, imperceptibility evaluation can be divided into subjective and objective two. The former name is based on the human to the image to determine image distortion. Subjective evaluation is divided into two steps: firstly, the distortion data sets bad sequence is divided into several levels. Then the test of watermark visibility into the description according to the degree of distortion of each data set.

One of the basic methods of image evaluation through analyzing and calculating is between the two image pixels, the image quality and the effect of. The calculation formula for MSE:

$$MSE = \frac{1}{M \times N} \sum_{x=1}^{M} \sum_{y=1}^{N} \left(I(x,y) - I'(x,y) \right)^2 \tag{6}$$

Signal to noise ratio refers to the ratio of the modified image and the original image, can be quantitatively distortion of digital image signal. The calculation formula for SNR:

$$SNR = 10 \lg \frac{\sum_{x=1}^{M} \sum_{y=1}^{N} I(x,y)^2}{\sum_{x=1}^{M} \sum_{y=1}^{N} \left(I(x,y) - I'(x,y) \right)^2} \tag{7}$$

Distortion of digital images of the PSNR quantitative is description. The calculation formula for PSNR:

$$PSNR = 10\lg\left[\frac{M \times N \times 255^2}{\sum_{x=1}^{M}\sum_{y=1}^{N}\left(I(x,y) - I'(x,y)\right)}\right] \tag{8}$$

The robustness of watermarking for specific performance of the image with watermark can be extracted accurately the capacity of watermark after malicious or non malicious attack. The normalized correlation coefficient (NC) is often used to measure the similarity between the original watermark and extracted watermark. The higher the NC value shows that the extracted watermark and the original watermark and the higher the degree of similarity, namely the anti-jamming algorithm is higher, and vice versa. For robustness, requires higher NC values; while for the fragile watermarking, NC values are generally lower. The NC value was calculated as:

$$NC = \frac{\sum_{x=1}^{M}\sum_{y=1}^{N} w(x,y) \times w'(x,y)}{\sum_{x=1}^{M}\sum_{y=1}^{N} \mathrm{w}(x,y)^2} \tag{9}$$

Among them, W, W' table was not extracted watermark and the original watermark, W' (x, y), w (x, y) are in the (x, y) value for the location of the watermark information, the size of M x N.

III. RESEARCH ON DIGITAL IMAGE WATERMARKING BASED ON DCT TRANSFORM AND ARNOLD TRANSFORM

3.1 Application of DCT and Arnold in digital image watermarking

Discrete cosine transform (DCT) is to transform and Fourier transform, it is similar to the discrete Fourier transform (DFT), but the only real coefficient.

For the two-dimensional matrix x is a M x N, discrete cosine transform defined it as follows:

$$Y(u,v) = a(u)a(v)\sum_{i=1}^{M-1}\sum_{j=1}^{N-1}\cos\frac{(2i+1)u\pi}{2M}\cos\frac{(2i+1)\mathrm{v}\pi}{2M} \tag{10}$$

$$a(u) = \begin{cases} \frac{1}{\sqrt{M}}, & u = 0 \\ \sqrt{\frac{2}{M}}, & u = 1,2,\ldots,M-1 \end{cases} \quad (11) \quad a(\mathrm{v}) = \begin{cases} \frac{1}{\sqrt{N}}, & \mathrm{v} = 0 \\ \sqrt{\frac{2}{N}}, & \mathrm{v} = 1,2,\ldots,N-1 \end{cases} \tag{12}$$

Through the transformation of Y called DCT coefficient matrix X, where Y (0,0) DCT DC coefficient matrix representation of X, the average energy value of DCT coefficient, the other said AC components of different frequency.

The extension of one dimensional discrete cosine transform to the two-dimensional discrete cosine transform, discrete cosine transform positive transformation kernel:

$$\begin{cases} g(x,y,0,0)=\frac{1}{N} \\ g(x,y,u,v)=\frac{1}{2\sqrt{(NN)^2}}[\cos(2x+1)u\pi][\cos(2y+1)v\pi] \end{cases} \quad (13)$$
$$(x,y=0,1,...,N-1;\ u,v=1,2,...,N-1)$$

3.2DWT combined with DCT in digital image watermarking using

Wavelet transform is a signal based on transform on the further development of theory, it can separate the frequency of the signal, and then more effective local signal analysis. The discrete wavelet transform in digital image, equivalent to the image of the row (column) for one-dimensional wavelet transform for image, then the column (row) for one-dimensional wavelet transform, decomposition is the essence of images of different resolution, the image is decomposed into different space, different frequency sub images. The digital image through a two-dimensional discrete wavelet transform, the sub image can get four space of equal size: low-frequency approximation sub graph LL1, high-frequency detail sub images of horizontal HL1, vertical high-frequency detail sub images LH1, diagonal high-frequency detail sub images HH1.

Figure 1 is the size of 512*512*256 gray level Lena image. If the low-frequency approximation sub image LL1 again for two dimensional discrete wavelet transform, can get two-level wavelet transform image of original image, and so on.

Figure 1. Lena images and a wavelet transform effect chart

High-frequency detail sub images of HH obtained by wavelet transform in digital image of the 3 sub - LH, HL and HH. diagonal contains the main image texture background and other details of the original image, human visual perception sensitivity to these information is low, in this part of the information in the watermark embedding operations can achieve better invisibility, but this part of the information in image processing operations are vulnerable to interference, and therefore can not guarantee the robustness of watermarking; while the low-frequency approximation sub image LL concentration of most of the energy of the original image, in the image processing operations in general will not be disturbed, so the watermark is embedded into the low-frequency approximation sub image in to obtain better robustness, but because the human visual perception is sensitive to this part of the information, thus the watermark information directly in the region of the embedded operation can not guarantee the imperceptibility of the watermark.

3.3 Expand the algorithm embedding process

Watermarking algorithm is expanded to two level wavelet transform of the carrier image, and then the approximation image block DCT coefficients, the improved embedded watermark embedding operation rules. Watermarking algorithm of extended embedding process is shown in Figure 2:

The specific steps are as follows:

Step1: of the watermarked image W values of two treatment, then the image was B Arnold transform scrambling, the watermarked image is obtained after pretreatment with W', then zigzag scan on the W', one-dimensional watermark information sequence of W (1, K);

Step2: two-dimensional DWT transform of the carrier image two level, two level approximation sub image LL1;

Step3: two level approximation sub image LL1 into K disjoint 8*8 block X;

Step4: discrete cosine transform for each sub block X, the DCT coefficient matrix Y, zigzag scans were performed on Y, DCT coefficient sequence F;

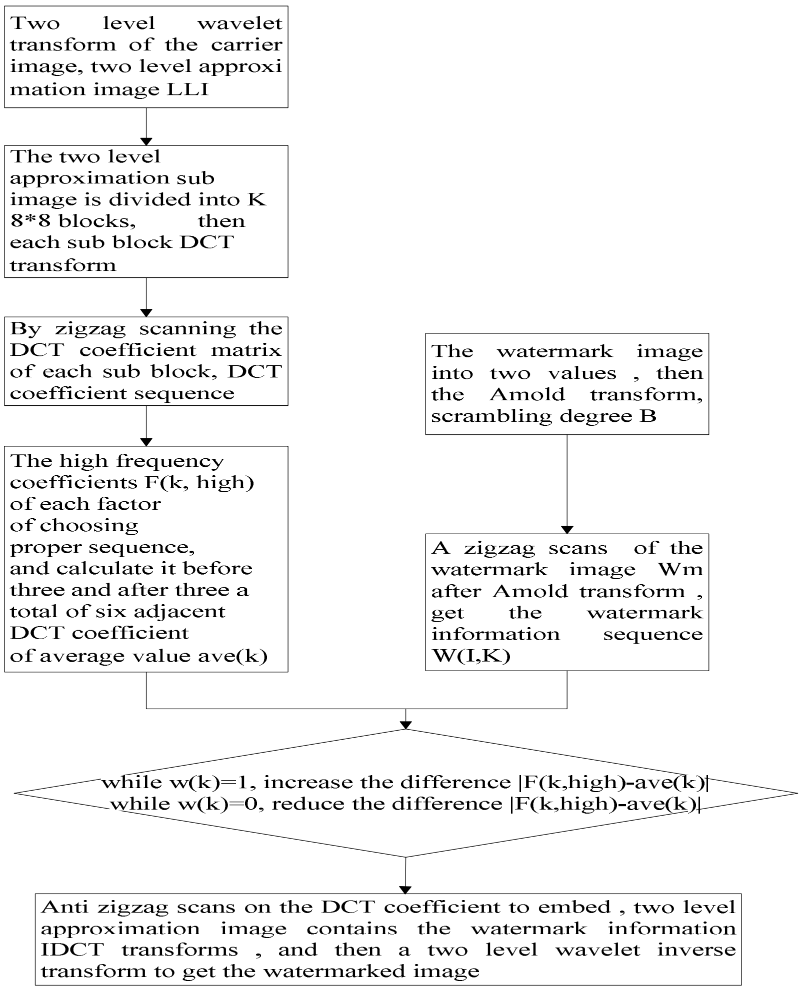


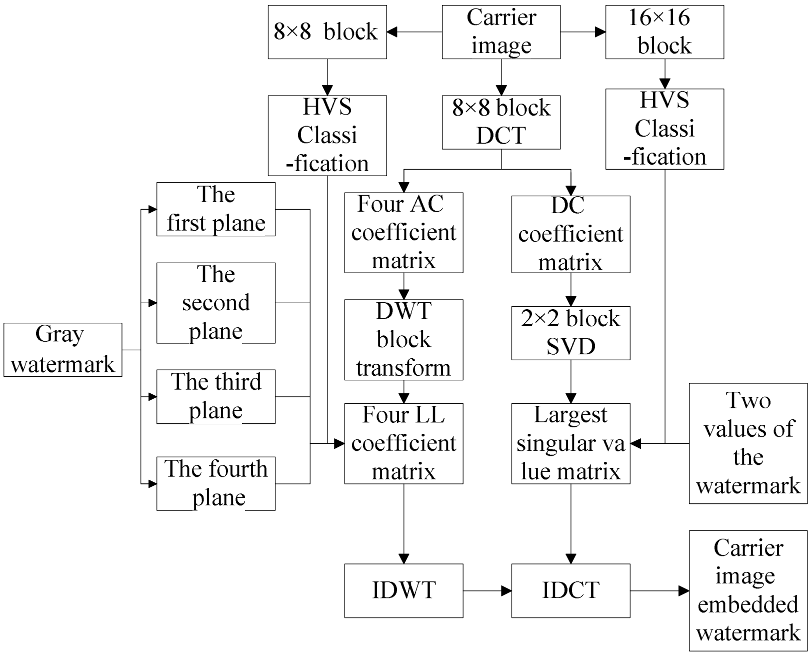
Figure 2. Embedding flow chart of Expansion algorithm combination of DCT transform and DWT transform

Step5: Select the appropriate high frequency DCT coefficients of F (k, high), according to the formula of each DCT coefficient sequence in F (k, high) average of 6 adjacent coefficients of ave (k), and according to the formula F (k, high) and ave (k) absolute difference between A(K);

$$ave(k) = \frac{1}{6}\left(\sum_{i=-3}^{-1} F(k, mid+i) + \sum_{j=1}^{3} F(k, mid+j)\right) \quad (14)$$

$$\Delta(k) = \left|F(k, high) - ave(k)\right| \quad (15)$$

Step6: watermark information sequence W(1, K) according to the following rule order approximation image sub block is embedded in high frequency DCT coefficients (where c is the volume control. The basic block diagram of watermark embedding was shown in Figure 3.



Basic block diagram of watermark embedding

Figure 3. The basic block diagram of watermark embedding

3.4 Two dimensional image wavelet decomposition and reconstruction

An image can be composed of a two-dimensional array f (x, y), where x and Y represent a coordinate position of 2D XY, f is the image of the point (x, y) based on some properties of F values, such as grey values in the image. The image is two-dimensional information, so the wavelet decomposition and reconstruction using 2D wavelet transform.

Design $f = f(x, y) \in V_j^2$ for the image signal to be analyzed, the two-dimensional approximation image formula:

$$A_j f = A_{j+1} f + D_{j+1}^1 f + D_{j+1}^2 f + D_{j+1}^3 f \tag{16}$$

$$A_{j+1} f = \sum_{m=-\infty}^{\infty} \sum_{n=-\infty}^{\infty} C_{j+1}(m,n)\phi_{j+1}(m,n) \tag{17}$$

The scaling function and orthogonal wavelet function, by the formula (18) -(19) available type (20):

$$D_{j+1}(m,n) = \sum_{k=-\infty}^{\infty} \sum_{j=-\infty}^{\infty} h(k-2m)h(l-2n)C_j(k,l) \quad j = 1,2,3 \tag{18}$$

$$D_{j+1}(m,n)=\sum_{k=-\infty}^{\infty}\sum_{j=-\infty}^{\infty}h(k-2m)h(l-2n)C_j(k,l) \tag{19}$$

$$\begin{cases} D_{j+1}^1(m,n)=\sum_{k=-\infty}^{\infty}\sum_{j=-\infty}^{\infty}h(k-2m)\mathrm{g}(l-2n)C_j(k,l) \\ D_{j+1}^2(m,n)=\sum_{k=-\infty}^{\infty}\sum_{j=-\infty}^{\infty}g(k-2m)h(l-2n)C_j(k,l) \\ D_{j+1}^3(m,n)=\sum_{k=-\infty}^{\infty}\sum_{j=-\infty}^{\infty}g(k-2m)\mathrm{g}(l-2n)C_j(k,l) \end{cases} \tag{20}$$

The two-dimensional wavelet decomposition and reconstruction algorithm is to use it, in the realization of the first for the one-dimensional wavelet transform, and then in the transformation based on the results as a one-dimensional wavelet transform. In practical application, because the image signal is limited area, so we need to consider how to deal with the boundary problem. Approach typical is the cycle expansion and extension of the reflection, it can decrease caused by boundary discontinuity at the boundary of transformation of slow decay.

The following figure two respectively on the decomposition and reconstruction of two-dimensional image algorithm shows. Mattiat Two dimensional wavelet decomposition (a) and reconstruction (b) algorithm was shown in Figure 4.

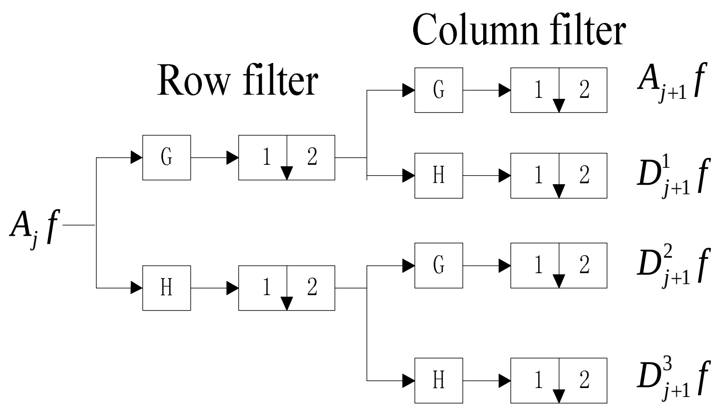


Figure 4. (a)Mattiat Two dimensional wavelet decomposition algorithm

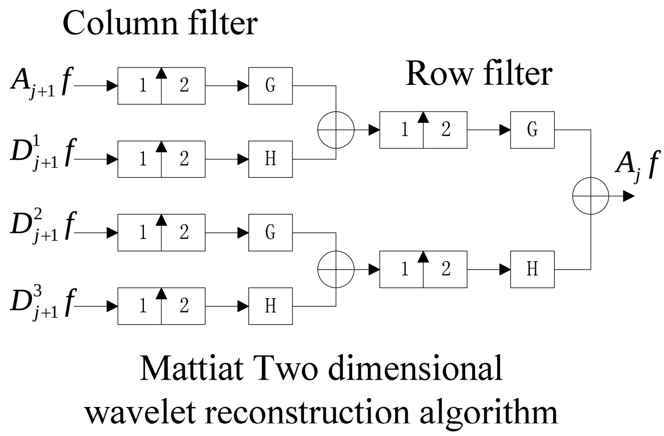


Figure 4. (a)Mattiat Two dimensional wavelet reconstruction algorithm

3.5Digital image scrambling technology

The so-called image scrambling, refers to the specific value of an image does not change its pixel, but merely to spatial arrangement, in order to eliminate the spatial correlation, which can not be identified visually; at the same time the scrambling can reach to a certain extent, to protect the image information, like the original image into a new image of a be, do not know what the transformation as well as the premise of using scrambling transformation frequency, it is difficult to restore the original image, which also makes the image information more secure. In digital image watermarking, image scrambling technology is the most popular Arnold transform.

Arnold transform, commonly known as cat map, as the image scrambling transformation it is represented by Russian mathematician V. I. Arnold in the research of the torus of the endomorphism. The need for digital images, two-dimensional Arnold transform to define the position of image scrambling based on the following:

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 1 & 1 \\ 1 & 2 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} (\bmod N) \quad (21)$$

The x, y (0.1.2.....N-1), representing the image matrix a pixel coordinates of points, and N is the number of order of image matrix, the transformation can be seen as the point (x, y) to (x', y') mapping.

Arnold transform is periodic, the order of different N number, Arnold transform has different cycles, Figure 5 showed image scrambling effect chart.

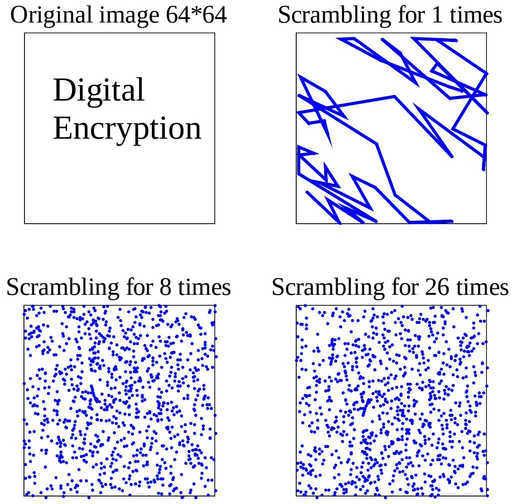


Figure 5. The image scrambling effect chart

IV. EXPERIMENTAL RESULTS

4.1Watermark embedding and extraction

In order to anti attack performance verification chaotic scrambling after the watermark image watermarking system, a classic image information hiding algorithm is proposed in this paper into the watermark embedding algorithm experiments show that, the main idea of the algorithm is dividing the image into blocks, and then the discrete cosine transform of image sub block (DCT), by adjusting the two DCT coefficients to embed the watermark, in order to consistent with the standard JPEG compression, the image block size in Table 1 for the quantization of image compression in JPEG 8x8 block using the coefficient table for the 8x8., the shading shadow area for the middle frequency region after DCT transform.

The original image according to the 8X8 block, respectively, for DCT transform Bj (U, V), the subscript j denotes the pieces.

Table 1. Quantitative value of JPEG image compression in 8×8 block

(u,v)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	10	11	10	26	24	40	51	61
2	12	11	14	19	26	58	60	55
3	14	13	16	24	40	57	69	56

4	14	17	22	24	51	87	80	62
5	18	22	37	56	68	10 9	10 3	77
6	24	35	55	68	81	10 4	11 3	92
7	49	64	78	87	10 3	12 1	12 2	10 1
8	72	92	95	98	11 2	10 0	10 3	97

By two DCT coefficient comparison to the size of each image block adjustment, two DCT coefficient selection should meet the adjustment will not their size leads to severe degradation of the carrier image, if so to choose the JPEG compression DCT transform coefficient algorithm. And from the digital watermarking system against JPEG compression robustness considerations, we select JPEG compression intensity quantization value coefficient; based on the above two factors, observation of Table 1, coefficient (5, 2) and (4, 3), or (2, 3) and (4, 1) is a better choice, this choice (5, 2) and (4, 3) a pair of coefficients, comparing their size, if not meet, exchange the values of the two coefficients:

$$\begin{cases} W_j = 0, & B_j(5,2) < B_j(4,3) \\ W_j = 1, & B_j(5,2) \geq B_j(4,3) \end{cases} \tag{22}$$

When the coefficient (5, 2) greater than the coefficient (4, 3) and the difference is less than P, press the adjustment:

$$\begin{cases} B_{W_j}(5,2) = B_{W_j}(5,2) + \beta / 2 \\ B_{W_j}(4,3) = B_{W_j}(4,3) - \beta / 2 \end{cases} \tag{23}$$

When the coefficient (4,3) greater than the coefficient (5,2) and the difference is less than P, press the adjustment:

$$\begin{cases} B_{W_j}(5,2) = B_{W_j}(5,2) - \beta / 2 \\ B_{W_j}(4,3) = B_{W_j}(4,3) + \beta / 2 \end{cases} \tag{24}$$

The finite Radon transform

For finite ridgelet transform for image, only the image block it into prime p*p size of each image block, the finite Radon transform to obtain Radon coefficient p+1 directions, do the 1D wavelet transform for each direction of the P coefficients, can be obtained by the finite ridgelet is changing at the same time; the inverse process, finite ridgelet transform is a transform, first for each direction of the ridgelet coefficients as one-dimensional wavelet transform, then make a finite radon transform Ridgelet transform as a flow chart in Figure 6.

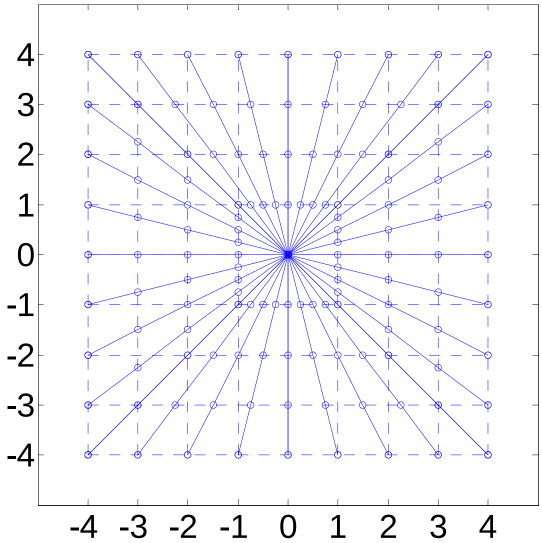


Figure 6. A finite radon transform

The ridgelet transform is transformed by Radon at first, and then wavelet transform, so the introduction of Radon transform and discrete data of projects to achieve the following: to achieve Radon transform on the basis of DFT, the first step of N*N discrete points for two dimensional FFT, and the included frequency domain point N*N point column radial division (which represents the frequency calculation, pending data points, connecting boundary point and center of the line is radial line), the second step estimation N data points of each radial direction (The intersection with the original mesh from the original value, otherwise, based around the point to estimate the value of fixed point the Department).

4.2Effect of NEC algorithm for image preprocessing

In the NEC algorithm to the whole image DCT transform before the carrier image scrambling, then make DCT transform, completed after embedding the watermark, then IDCT transform image after inverse scrambling to get the watermark image.

Figure 7 the scrambling and scrambling algorithm without carrier NEC image watermark detection response comparison chart, the abscissa of the random watermark sequence seed, longitudinal coordinates for the watermark detector output value and use, namely the extraction of the watermark with the original watermark correlation. As can be seen from the graph, image scrambling, watermark sequence of the seeds were embedded into the carrier image, detected and compared to the carrier image not scrambling is slightly higher, that scrambling image pixel after remove the correlation between the carrier image, the DCT variable. Transform domain random sequence is embedded watermark can greatly enhance the value of small correlated random sequence watermark detection.

Figure 8 the scrambling and scrambling algorithm of NEC image without carrier in JPEG compression attacks watermark detection response graph, the abscissa is shown in the watermarked image by the quality factor Q JPEG compression attack value, Q is larger, better quality of image compression, compression rate is low; the smaller the Q, image compression quality is poorer, the compression rate is high. The ordinate is shown in the watermark detector output value SIM, as can be seen, scrambling carrier, its anti JPEG compression attack performance drops quickly.

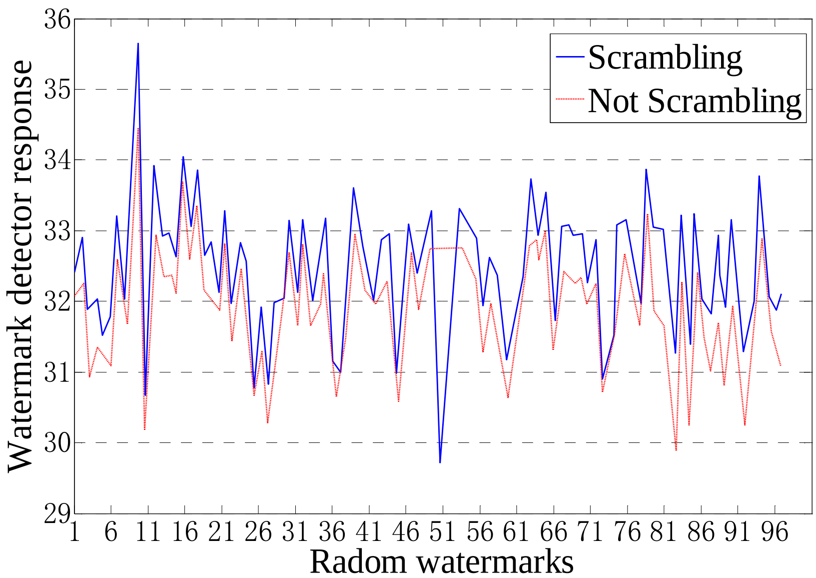


Figure 7. The scrambling and scrambling algorithm without carrier NEC image watermark detection response

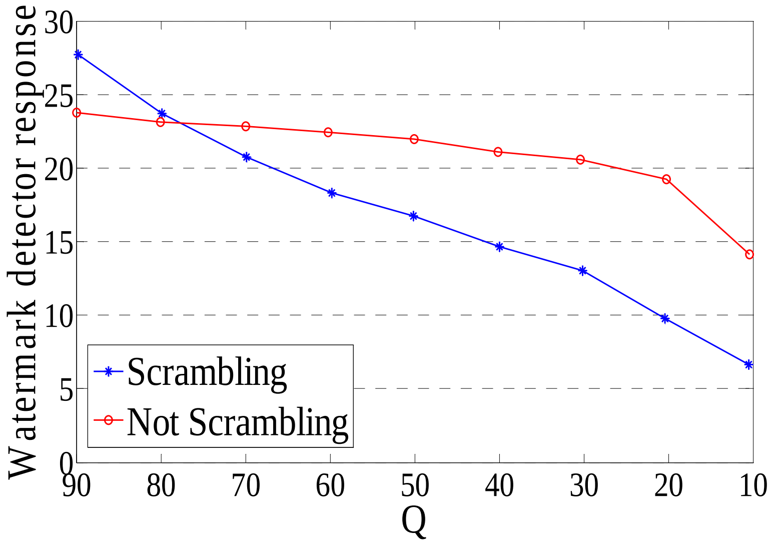


Figure 8. The scrambling and scrambling algorithm of NEC image

4.3Algorithm performance before and after improvement

Comparison of the data, as shown in Figure 9, obviously, the improved algorithm is less interference on the carrier image, so it has better imperceptibility.

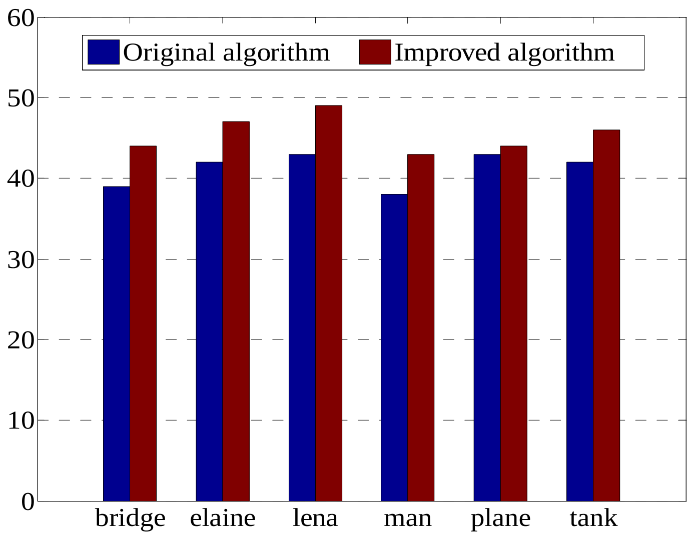


Figure 9. PSNR performance test algorithms before and after improved

Comparing the data, the results are shown in Figure 10, you can see the improved algorithm for various image attacks has better robustness.

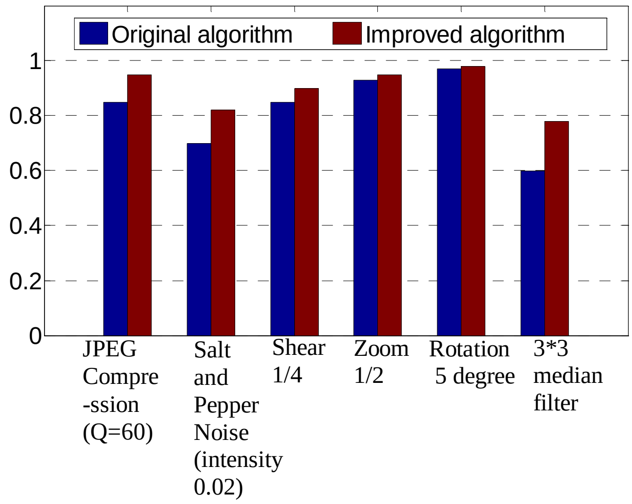


Figure 10. NC performance test algorithms before and after improved

V. CONCLUSIONS

This paper introduced the digital image watermarking technology and theory. Some current algorithms do a further analysis and research, proposed one kind based on the transform domain digital watermarking algorithm and self dual recovery technology, simulation results show that, this method is feasible in theory and practice. Then, on a digital image watermarking algorithm based on discrete cosine transform simulation. The simulation results show that, the algorithm is simple, easy to implement, has good security, invisibility and robustness, and belongs to the watermarking algorithm for blind extraction, and has a certain practical value. Then the algorithm for DCT coefficients are directly modify the approach has some shortcomings, this paper proposed an improved algorithm. The improved algorithm is also based on the discrete cosine transform, but the difference to modify the adjacent DCT coefficient to realize the watermark embedding, has a certain degree of adaptability. Then the simulation study of a digital image watermarking algorithm based on DCT transform and DWT transform. Combined treatment of the algorithm using wavelet multi-resolution decomposition and discrete cosine transform, achieve the watermark robustness and invisibility of organic coordination. For the shortcomings of the algorithm, this paper presents a digital image watermarking algorithm based on DCT transform and improved DWT transform based on basic idea from its balance watermark robustness and invisibility.

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