To study Digital watermarking technique based on DCT and DWT.

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Abstract—
Digital Watermarking is one of the data hiding technique, has been popular in today for providing copyright protection. Fundamentally, to implement a digital watermarking, there are two approaches, pixel modification based and frequency domain based. In frequency domain based watermarking techniques, DCT and DWT are commonly used and popular today Watermarking embedded in frequency domain using DWT or DCT can affect the imperceptibility and robustness of watermarking. In order to compare the imperceptibility & robustness of the both algorithms make use of simple attacks such as resizing, rotation &cropping.

Index Terms—
Digital watermarking, Discrete cosine transform (DCT), Discrete wavelet transforms (DWT), and Peak Signal to Noise Ratio (PSNR), Mean squared Error (MSE)

I. INTRODUCTION

At present, our digital era provides many economic opportunities such as cheap distribution and also faces serious risks in distribution of illegal copies.

Since digital multimedia have become progressively advanced in the rapidly growing field of internet application, data securities, including copyright protection and data integrity detection, have become a vast concern. One key for achieving information security is digital watermarking, which embeds hidden information or secret data in the image [1]. This technology works as a suitable tool for identifying the source, creator, owner, distributor, or authorized consumer of a document or image. Also watermarking can be used to detect a document or image is illegally distributed or modified [2].

Watermark techniques can be divided into two groups: Visible and invisible, the visible watermark is used if embedded watermark is intended to be seen by human eyes, For example, a logo inserted into corner of an image. While the invisible watermark is embedded into a host image by sophisticated algorithms and is invisible to the human eyes [3]

According to the embedding, watermarking techniques divided into two embedding domain, spatial domain and frequency domain [3, 9].The main concept of spatial domain [10] is to insert a watermark into an image by modifying the gray value of certain pixels in the image [11, 12]. The classical methods are to modify the last significant bits (LSB) of specific pixels of the host image based on the watermark bits [3].For frequency domain, themain concept to insert a watermark into frequency coefficients of the transformed image using the discrete cosine transform (DCT), the discrete wavelet transform (DWT) [13], or other kind of transforms techniques [3, 9]. There are requirements and constraints in design effective watermarking algorithms the three fundamental amongst it are:

- Imperceptibility: should the difference between the watermarked image and the original image not noticeable and visible by human eyes,
- Robustness: is the ability of watermarking to survive and withstand any intentional or unintentional attacks,
- Capacity: is the number of bits embedded into the original image

The above watermarking requirements are conflicting with each other. If watermark is embedding bits into higher frequency coefficient would change the image as little as possible and achieve the imperceptibility. However, that would reduce the robustness since the watermarked image may experience filtering and the hidden watermark may be vanished. Also if watermark is Embedding bits into lower frequency coefficient would increase the robustness. However, this would sacrifice the imperceptibility [14],[15]. The watermarking problem can be viewed as an optimization problem. Therefore, genetic algorithm (GA) can be used for solving such problem [16], [17].

Watermarking embedding domain:

2.1 Discrete Cosine Transform (DCT): Discrete cosine transform (DCT) is a general orthogonal transform for digital image processing and signal processing, with such advantages, as high compression ratio, small bit error rate, good information integration ability and good synthetic effect of calculation complexity. DCT is a widely used mechanism for image transformation and has been adopted by JPEG to compress images; discrete cosine transform (DCT) is a Fourier-related transform similar to the discrete Fourier transform, (DFT) [18]. Discrete cosine transform (DCT) turn over the image edge to make the image transformed into the form of even function [19]. It's one of the most common linear transformations in digital signal process technology. The DCT allows an image to be broken up into different frequency bands, making it much easier to embed watermarking information into the middle frequency bands of an image. The middle frequency bands are chosen such that the most visual important parts of the image (low frequencies) is to be avoided without over-exposing it to removal through compression and noise attacks (high frequencies)[20]. In DCT domain, DC component is more suitable to embed watermark than AC component (AC). Firstly, DC component has larger perceptual capacity. So, after embedding watermark it doesn't cause obvious change for visual quality of original image; secondly, signal processing and noise interference have smaller influence for DC component than AC component [21].

The DCT coefficients for output image are computed according to the input as equation.1. Where is the input image with size pixels, is the raw and is the column of the image, whereas is the DCT matrix.

$$T(u,v) = \alpha_u \alpha_v \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y).\cos\frac{(2x+1)u\pi}{2M}.\cos\frac{(2y+1)v\pi}{2N}$$

where

$$\alpha_u = \alpha_v = \begin{cases} \sqrt{\frac{1}{M}} & u = v = 0 \\ \sqrt{\frac{2}{N}} & u \neq v \neq 0 \end{cases}$$

The image recreated by applying inverse DCT according to equation 2.

$$\alpha_u \alpha_v \sum_{x=0}^{M-1} \sum_{v=0}^{N-1} T(u,v).\cos\frac{(2x+1)u\pi}{2M}.\cos\frac{(2y+1)}{2N}$$

Discrete Wavelet Transform (DWT):

The wavelet transformation is a mathematical tool that can examine an image in time and frequency domains, simultaneously [22]. Discrete wavelet transform (DWT) is simple and fast transformation approach that translates an image from spatial domain to frequency domain. The DWT provides a number of powerful image processing algorithms including noise reduction, edge detection, and compression [23].

Advantages of DWT over DCT:

According to [24] and [25], there is the DWT advantage over DCT as:

1. No need to divide the input coding into non-overlapping 2-D blocks, it has higher compression ratios avoid blocking artifacts.

2. Allows good localization both in time and spatial frequency domain.

3. Transformation of the whole image introduces inherent scaling

4. Better identification of which data is relevant to human perception higher compression ratio

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Genetic Algorithms

Genetic Algorithms (GAs) introduced by Holland [26].GA is most widely used amongst the artificial optimization intelligent techniques. A GA is a stochastic searching algorithm based on the mechanisms of natural selection and genetics. GAs has been proven to be very efficient and stable in searching for global optimum solutions

In general, GAs start with some randomly selected population, called the first generation. Each individual in the population called chromosome and corresponds to a solution in the problem domain. An objective called fitness function is used to evaluate the quality of each chromosome. The next generation will be generated from some chromosomes whose fitness values are high. Reproduction, crossover and mutation are the three basic operators used to repeat many time until a predefined condition is satisfied or the desired number of iteration is reached. According to the applications for optimization, designers need to carefully define the necessary elements for dealing with the GA. Then, the fitness function in addition to the terminating criteria is evaluated with the natural selection, crossover, and mutation operations [27].

Watermarking based on GA related works

Researchers used GA to optimize the watermarking requirements, Wang et al [28] presented watermarking based on Genetic algorithm. They used bit substitution method. Huang et al [29] proposed watermarking method based on GA and DCT domain. They embedded watermark with visually recognizable patterns into image by selection modifying the middle frequency parts of the image. The GA is applied to search for the locations to embed into DCT coefficient block. In addition, Hsiang et al [16] proposed a robust watermarking based on DCT and GA. They tried to design a particle fitness function to solve the tread-off between the three watermarking matrices. On the other hand, they have considered the capacity to be constant. Moreover, Hsiang et al [30] have proposed watermarking based wavelet packet transform (WPT). They have assumed watermarked consists of 0's and 1's all bits of the watermark are embedded into host image. Also, Promcharoen and Rangsanseri [31] presented new approach for watermarking based on DCT. The authors used fuzzy C-mean (FCM) to classify the 8*8 block to texture or non-texture region. They used GA to find out the optimized parameter. As well as, Patra et al [32] proposed the digital watermarking scheme based on singular value decomposition (SVD). The authors used GA to optimize the conflict between quality and robustness. They used Sun et al algorithm for quantization embedding. Furthermore, Li et al [33] proposed watermarking based on DWT domain. They used Arnold transform and GA to improve the performance of watermarking algorithm.

DISCRETE COSINE TRANSFORM (DCT)

The Discrete cosine transform (DCT) is most popular due to several reasons. One of the reason is that most of the compression techniques developed in the DCT domain (JPEG, MPEG, MPEG1, and MPEG2) & therefore image processing is more familiar with it.
DCT is one of the most common linear transformations in digital signal process technology.

Two-dimensional discrete cosine transform (2D-DCT) is defined as

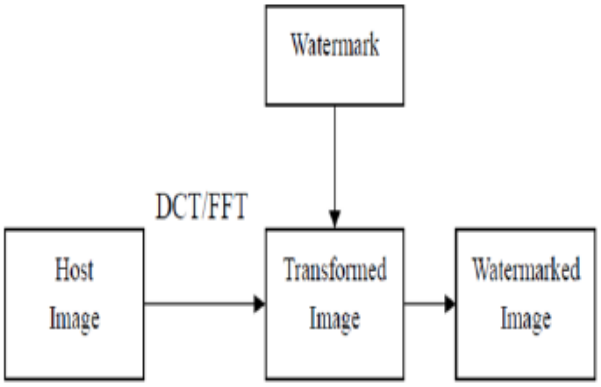
$$F(jk)=a(j)a(k)\sum_{m=0}^{N-1}\sum_{n=0}^{N-1}f(mm)\cos\left[\frac{(2m+1)j\pi}{2N}\right]\cos\left[\frac{(2n+1)k\pi}{2N}\right]$$

The corresponding inverse transformation (Whether 2DIDCT) is defined as

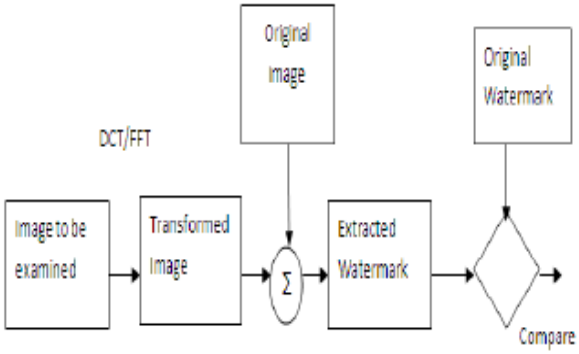
$$f(mm)=\sum_{m=0}^{N-1}\sum_{n=0}^{N-1}a(j)a(k)F(jk)\cos\left[\frac{(2m+1)j\pi}{2N}\right]\cos\left[\frac{(2n+1)k\pi}{2N}\right]$$

The 2D-DCT can not only concentrate the main information of original image into the smallest low frequency coefficient, but also it can cause the image blocking effect being the smallest, which can realize the good compromise between the information centralizing and the computing complication [3]. The DCT allows an image to be broken up into different frequency bands, making it much easier to embed watermarking information into the middle frequency bands of an image. In order to invisibly embed the watermark that can survive lossy data compressions, a reasonable tradeoff is to embed the watermark into the middle-frequency range of the image.

The middle frequency bands are chosen such that they have minimized that they avoid the most visual important parts of the image (low frequency) without over-exposing themselves to removal through compression and noise attacks. DCT domain watermarking can survive against the attacks such as noising, compression, sharpening, and filtering.



Watermark Embedding in DCT



Watermark Detection in DCT

DISCRETE WAVELET TRANSFORM (DWT)

Discrete wavelet transforms (DWT), which transforms a discrete time signal to a discrete wavelet representation. It converts an input series x_0, x_1,x_m, into one high-pass wavelet coefficient series and one low-pass wavelet coefficient series (of length n/2 each) given by:

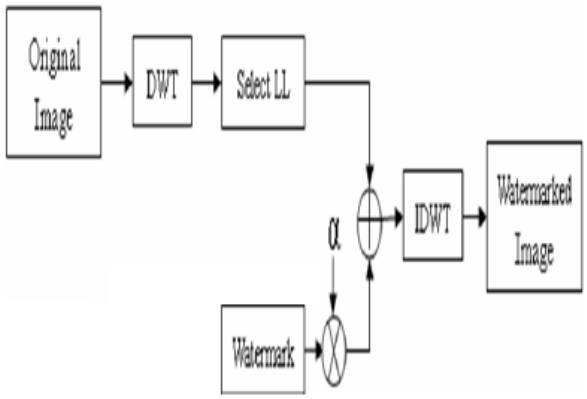
$$H_i = \sum_{m=0}^{k-1} x_{2i-m} \cdot s_m(z)$$

$$L_i = \sum_{m=0}^{k-1} x_{2i-m} \cdot t_m(z)$$

Where
$S_m(Z)$, $t_m(Z)$: wavelet filters,
K: the length of the filter, and i=0... [N/2]-1.

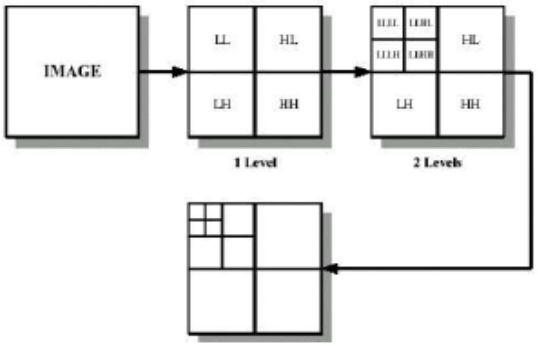
In practice, such transformation will be applied recursively on the low-pass series until the desired number of iterations is reached.

The new JPEG2000 standard has adopted a new technique, the wavelet transform. The basic idea in the DWT for a one dimensional signal is the following. A signal is split into two parts, usually high frequencies and low frequencies. The edge components of the signal are largely to the high frequency part. The low frequency part is split again into two parts of high and low frequencies. This process is continued an arbitrary number of times, which is usually determined by the application at hand



Watermark Embedding using DWT

A step of wavelet transform decomposes an image into four parts: HH, HL, LH and LL in Figure. LL is low frequency coefficient, LH is high frequency coefficient horizontally, HL is high frequency coefficient vertically, and HH is high frequency coefficient diagonally. Watermark should be embedded in low frequency coefficients.



Flow of DWT Process

Scale -2 Dimensional DWT

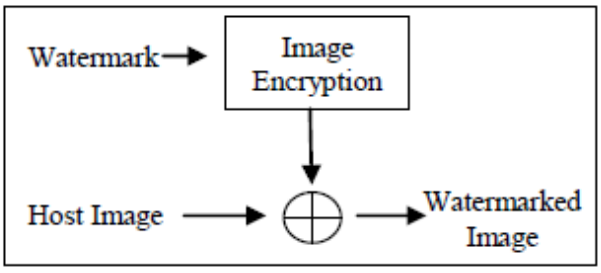
One of the many advantages, the discrete wavelet transform is the watermarking method has multi resolution characteristics and is hierarchical.DWT has effective also in structural attacks as compare to DCT. DWT has significant advantages over geometric attacks such as compression, scaling & cropping. It is generally observed that DWT is more robust to cropping.

One more advantage of DWT is that it shows acceptable performance with scaling attacks whereas DCT technique doesn't work with scaling attacks.

THEORETICAL ISSUE

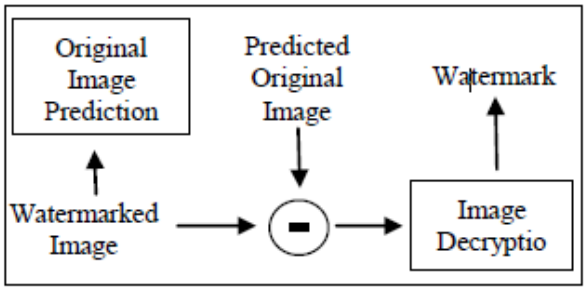
There are mainly two parts in every digital watermarking technique. These two parts are embedding in which watermark is inserted and watermark extraction in which watermark is recovered.

The spatial domain approached digital watermarking techniques are not too much complex. In the watermark embedding, watermark energy is directly added or subtracted to the corresponding host or cover image pixel. In the other word, the watermark embedding process can be seen as the addition of watermark and host image and the output is watermarked image. The embedding process can be demonstrated as follow



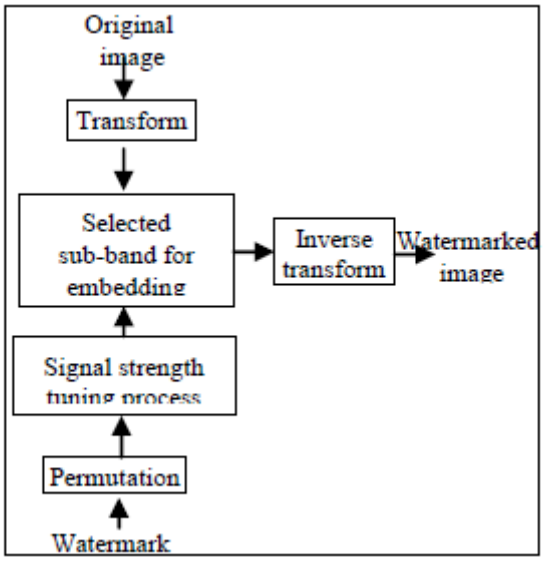
Watermark Embedding Process in spatial domain

On another side, in the watermark recovery process, original host image can be predicted and estimated from watermarked image by removing modified watermarked pixels and replacing with the best neighbor pixels. This process is called original image prediction and the result image of the process is predicted original image, not original image. By this way, embedded watermark can be recovered by subtraction of predicted original image from watermarked image. The processes can be illustrated as followed

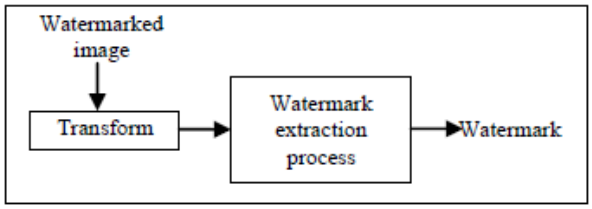


Watermark Extraction Process in spatial domain

In the extraction process, several different extraction methods are used according to embedded algorithm. Commonly, averaging and correlation are used in most of the method to extract watermark bit because they are simple and efficient. The following figures describe the embedding and extraction processes in the frequency domain based watermarking.



Watermark Embedding Process in frequency domain



Watermark Extraction Process in frequency domain

The frequency domain transform based algorithms are slow compared with spatial domain based. Although frequency domain approaches methods are robust against compression and filtering attacks but weak in geometrical attacks [10]. However, they can give better perceptual transparency.

CONCLUSION

In this paper we have represent various technique based on DWT and DCT, by studying various technique and method based on DWT and DCT it is shown that DWT provide better performance than DCT.

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References

[1] Y.-T. Wu, and F. Y. Shih, "Digital watermarking based on chaotic map and reference register," *Pattern Recognition,* vol. 40, no. 12, pp. 3753-3763, 2007.

[2] F. Shih, and Y.-T. Wu, "Information Hiding by Digital Watermarking," *Information Hiding and Applications,* vol. 227, pp. 205-223, 2009.

[3] F.-H. Wang, J.-S. Pan, and L. Jain, "Intelligent Techniques," *Innovations in Digital Watermarking Techniques*, Studies in Computational Intelligence, pp. 27-44: Springer Berlin / Heidelberg, 2009.

[4] I. J. Cox, J. Kilian, F. T. Leighton *et al.*, "Secure spread spectrum watermarking for multimedia," *Image Processing, IEEE Transactions on,* vol. 6, no. 12, pp. 1673-1687, 1997.

[5] P. L. Lin, "Oblivious digital watermarking scheme with blob-oriented and modular-arithmetic-based spatial-domain mechanism," *Journal of Visual Communication and Image Representation,* vol. 12, no. 2, pp. 136-151, 2001.

[6] F. Deguillaume, S. Voloshynovskiy, and T. Pun, "Secure hybrid robust watermarking resistant against tampering and copy attack," *Signal Processing,* vol. 83, no. 10, pp. 2133-2170, 2003.

[7] S. Agreste, G. Andaloro, D. Prestipino *et al.*, "An image adaptive, wavelet-based watermarking of digital images," *Journal of Computational and Applied Mathematics,* vol. 210, no. 1-2, pp. 13-21, 2007.

[8] S.-k. Je, C.-j. Seo, J.-y. Lee *et al.*, "Self-organizing Coefficient for Semi-blind Watermarking," *Web Technologies and Applications*, Lecture Notes in Computer Science X. Zhou, M. Orlowska and Y. Zhang, eds., pp. 596-596: Springer Berlin / Heidelberg, 2003.

[9] F. Shih, "Digital Watermarking and Steganography FANDAMENTALS AND TECHHNIQUES," *CRC Press*, 2008.

[10] W. N. Cheung, "Digital image watermarking in spatial and transform domains." pp. 374-378 vol.3.

[11] M. Ramkumar, "Data Hiding in Multimedia - Theory and Applications," Ph.D.Thesis, New Jersey Institute of Technology, Newark, New Jersey, 2000.

[12] K. A. Navas, M. Sasikumar, and S. Sreevidya, "A Benchmark for Medical Image Watermarking." pp. 237-240.

[13] M. a. K. Vetterli, *Wavelets and Subband Coding*: Prentice Hall, 1995.

[14] A. Phadikar, and S. P. Maity, "Multibit QIM watermarking using M-ary modulation and lifting." pp. 1-5.

[15] H.-C. Huang, C.-M. Chu, and J.-S. Pan, "Genetic Watermarking for Copyright Protection," *Information Hiding and Applications,* vol. 227, pp. 1-19, 2009.

[16] C.-M. C. a. J.-S. P. Hsiang-Cheh Huang, "The optimized copyright protection system with genetic watermarking," *A FUSION OF FOUNDATIONS, METHODOLOGIES AND APPLICATIONS,* vol. 13, 2008.

[17] W. Shih-Hao, and L. Yuan-Pei, "Wavelet tree quantization for copyright protection watermarking," *Image Processing, IEEE Transactions on,* vol. 13, no. 2, pp. 154-165, 2004.

[18] C.-M. P. a. I.-T. Lam, "Fingerprint Watermark Embedding by Discrete Cosine Transform for Copyright Ownership Authentication," *INTERNATIONAL JOURNAL OF COMMUNICATIONS,* vol. 3, no. 1, pp. 8, 2009.

[19] M. Jiansheng, L. Sukang, and T. Xiaomei, "A Digital Watermarking Algorithm Based On DCT and DWT," *International Symposium on Web Information Systems and Applications (WISA'09)*, 2009.

[20] I. El-Fegh, D. Mustafa, Z. S. Zubi *et al.*, "Color image watermarking based on the DCT-domain of three RGB color channels," in Proceedings of the 10th WSEAS international conference on evolutionary computing, Prague, Czech Republic, 2009, pp. 36-39.

[21] M. Eyadat, and S. Vasikarla, "Performance evaluation of an incorporated DCT block-based watermarking algorithm with human visual system model," *Pattern Recognition Letters,* vol. 26, no. 10, pp. 1405-1411, 2005.

[22] M. Ouhsain, and A. B. Hamza, "Image watermarking scheme using nonnegative matrix factorization and wavelet transform," *Expert Syst. Appl.,* vol. 36, no. 2, pp. 2123-2129, 2009.

[23] C.-Y. Chang, H.-J. Wang, and S.-W. Pan, "A robust DWT-based copyright verification scheme with Fuzzy ART," *Journal of Systems and Software,* vol. 82, no. 11, pp. 1906-1915, 2009.

[24] m. S. J. a. N. B. Hingoliwala H.A., "An image comperession by using haar wavelet transform," *Advances in Computer Vision and Information Technology*, 2008.

[25] D. P. R. K. V.Srinivasa rao, G.V.H.Prasad, M.Prema Kumar, S.Ravichand, "Discrete Cosine Transform Vs Discrete Wavelet Transform: An Objective Comparison of Image Compression Techniques for JPEG Encoder," *International Journal of Advanced Engineering & Applications,*, Jan 2010.

[26] J. H. Holland, "Adaptation in Natural and Artifcial Systems,," *The University of Michigan Press, Ann Arbor, MI*, 1975.

[27] M. Gen, and R. Cheng, *Job-Shop Scheduling Problems*: John Wiley & Sons, Inc., 2007.

[28] R.-Z. Wang, C.-F. Lin, and J.-C. Lin, "Image hiding by optimal LSB substitution and genetic algorithm," *Pattern Recognition,* vol. 34, no. 3, pp. 671-683, 2001.

[29] C.-H. Huang, and J.-L. Wu, "Watermark optimization technique based on genetic algorithms." pp. 516-523.

[30] H. Hsiang-Cheh, C. Yueh-Hong, and L. Guan-Yu, "DCT-Based Robust Watermarking with Swarm Intelligence Concepts." pp. 464-467.
[31] S. Promcharoen, and Y. Rangsanseri, "Genetic watermarking based on texture analysis in DCT domain." pp. 25-28.

[32] J. C. Patra, J. E. Phua, and C. Bornand, "A novel DCT domain CRT-based watermarking scheme for image authentication surviving JPEG compression," *Digital Signal Processing,* vol. 20, no. 6, pp. 1597-1611, 2010.

[33] H.-f. Li, N. Chang, and X.-m. Chen, "A study on image digital watermarking based on wavelet transform," *The Journal of China Universities of Posts and Telecommunications,* vol. 17, no. Supplement 1, pp. 122-126, 2010.
[34] T. Kumaran, and P. Thangavel, "Watermarking in Contourlet Transform Domain Using Genetic Algorithm." pp. 257-262.
[35] Z. Ning, H. Zunwen, K. Jingming *et al.*, "An Optimal Wavelet-Based Image Watermarking via Genetic Algorithm." pp. 103-107.
[36] C. Yueh-Hong, and H. Hsiang-Cheh, "Genetic Watermarking Based on Wavelet Packet Transform." pp. 262-265.
[37] S.-C. Chu, H.-C. Huang, Y. Shi *et al.*, "Genetic Watermarking for Zerotree-Based Applications," *Circuits, Systems, and Signal Processing,* vol. 27, no. 2, pp. 171-182, 2008.
[38] Y. Lu, J. Han, J. Kong *et al.*, "A Novel Color Image Watermarking Method Based on Genetic Algorithm and Hybrid Neural Networks," *Rough Sets and Current Trends in Computing*, Lecture Notes in Computer Science S. Greco, Y. Hata, S. Hirano *et al.*, eds., pp. 806-814: Springer Berlin / Heidelberg, 2006.
[39] M. Rafigh, and M. E. Moghaddam, "A Robust Evolutionary Based Digital Image Watermarking Technique in DCT Domain." pp. 105-109.
[40] L. Jiann-Shu, C. Fong-Ping, and T. Kuen-Horng, "Image Watermarking Based on Multiple Objective Genetic Algorithm." pp. 102-105.
[41] C.-S. Shieh, H.-C. Huang, F.-H. Wang *et al.*, "Genetic watermarking based on transform-domain techniques," *Pattern Recognition,* vol. 37, no. 3, pp. 555-565, 2004.
[42] C. Chi-Ming, H. Hsiang-Cheh, and P. Jeng-Shyang, "An Adaptive Implementation for DCT-Based Robust Watermarking with Genetic Algorithm." pp. 19-19.
[43] S. Promcharoen, and Y. Rangsanseri, "Genetic Watermarking with Block-Based DCT Clustering." pp. 346-351.

[44] T. Kumaran, and P. Thangavel, "Genetic algorithm based watermarking in double-density dual-tree DWT." pp. 585-590.

