Performance Analysis of Image Authentication between DCT and DWT Watermarking

Mya Thidar Kyaw, Kyi Soe
University of Technology, Yatanarpon Cyber City
Pyin Oo Lwin, Myanmar
myathidarkyawmin@gmail.com, kyisoe72@gmail.com

Abstract

Security has become one of the most significant and challenging problems for spreading new information technology. Security requirements are met by security measures, which generally consist of several security mechanisms such as cryptographic mechanisms and digital watermarking techniques. In this paper, image authentication between Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) watermarking is analyzed in performance comparison. On-line handwritten signature is acquired G-Pen F350 tablet encodes the signature which creates own signature image of different users and is used as watermark. The same digital watermarking embedding and extracting algorithms based on DCT and DWT are discussed and implemented. As in experimental results for the robustness and performance comparison, Peak Signal to Noise Ratio (PSNR) and Normal Correlation (NC) are estimated from different standard images.

Keywords: Image Authentication, cryptographic mechanism, digital watermarking, DCT, DWT.

1. Introduction

Digital media become popular in the past few years partly because of their efficiency of manipulation. Today, most of the people widely use internet and get up-to-date information from more online media (journals) than printed media (journals). In the media, multimedia data such as photo, sound and video are suffered from illegal copy and various modification in time and time as the rapidly development of digital technology. Hence, copy right prevention become to play an important role in media world. The image authentication system is considered to overcome these problems.

The contributions of this system are as follow. In the key generation process, on-line handwritten signature image is converted to binary image and normalized to standard size. The binary image is permutated with a key for security purpose. Original image is transformed in Discrete Cosine Transform (DCT) domain and Discrete Wavelet Transform (DWT) domain and then the same embedding and extracting algorithms for the DCT and DWT watermarking are used in this system.

Section 2 discusses related works of watermarking techniques. In Section 3, discrete cosine transform is briefly described. In Section 4, discrete wavelet transform is presented. Watermark embedding and extracting algorithms using DCT and DWT are discussed in section 5. In Section 6, experimental results are discussed and section 7 concludes our discussion and states the future work of watermarking scheme.

2. Related Works

In digital image watermarking technique, there are two domains for a embedding a watermark, namely frequency domain and spatial domain [1] and [2]. In the frequency domain, a watermark is embedded to coefficients of the transformed image, while in spatial domain; it is directly embedded in host image pixels. In the past, there are many previous works in digital watermarking based on the both domains have been proposed.

In [3], the authors proposed a spatial watermarking technique for gray scale images. The algorithm is implemented via pixel by pixel comparison between host image and watermark. For the each pixel of host image, it compared with correspond value in watermark. If they are equal it position is used as key. First two positions of key vector are the dimensions of watermark. In result this algorithm was found to be robust against many attacks.

A new watermarking technique for color images is introduced in [4]. It embedded four identical watermarks into blue component of host image. In the extraction process, the original image is available and five watermarks can be extracted from different region of the watermarked image and only one watermark is detected or constructed from the five watermarks according to the highest value of normalized cross correlation (NCC).

A collusion attack resistant watermarking scheme of Colored images using DCT was reported in [5]. It improved on the classical middle band coefficient Exchange watermarking scheme by averaging of middle frequency coefficients of the image.

In [6], a watermarking technique in transform domain was proposed by taking DWT of an image and adding PN sequences to H1 and V1 components of the image. The proposed technique is proved to be resistant to JPEG compression, cropping.

In [7], authors implemented different watermarking algorithms using MATLAB SIMULINK based on DCT, DWT and combination of DCT & DWT transform. Simulation results show that DWT is somewhat better than DCT but, combination of these two gives much better result results than individual one. The capability of watermarking algorithm is robust to salt & pepper, enhancement and speckle, but somewhat weaker to rotate and Gaussian noise.

In [8], it introduces an algorithm of digital watermarking based on DCT and DWT based on human vision characters. In this system, watermarking signal is embedded into the high frequency band of wavelet transformation domain. The simulation results suggest that this watermarking system not only can keep the image quality well, but also can be robust against many common image processing operations of filer, sharp enhancing, adding salt noise, image compression, image cutting.

In [9], the authors described an imperceptible and a robust combined DWT-DCT digital image watermarking algorithm. The algorithm watermarks a given digital image using a combination of the Discrete Wavelet Transform (DWT) and the Discrete Cosine Transform (DCT). Performance evaluation results show that combining the two transforms improved the performance of the watermarking algorithms that are based solely on the DWT transform. The watermarking technique based on DWT (Discrete Wavelet Transform) was presented in [10]. In this technique the insertion and extraction of the watermark in the grayscale image is found to be simpler than other transform techniques.

3. Discrete Cosine Transform

In digital watermarking, orthogonal transformation is used for the watermark embedding process to embed a watermark signal into the frequency domain of the image. Embedding in the frequency domain is commonly used because this method is able to limit the damage to the content rather than embedding the signal to the image directly.

There are several methods to transform an image to frequency domain, such as discrete Fourier transform (DFT), Discrete Cosine Transform (DCT), and discrete wavelet transform (DWT). DCT is used in this framework of transforming frequency domain. Discrete cosine transform is one method of Orthogonal transformation. The image compression using DCT orthogonally transforms the small blocks in the image.

Discrete cosine transform divides an image into $N*N$ pixel small blocks. The transformation will be processed independently to the individual *N*N* blocks. When expressing the coefficients after the discrete cosine transform as *D(i,j)*, the discrete cosine transform function, and inverse discrete cosine transform function to the *N*N* block of two dimensional image signal *p(x,y)* is as follows.

DCT function of *N*N* two dimensional image shows in equation (1) which computes the i,jth of the DCT an image.

$$D(i,j) = \frac{1}{\sqrt{2N}} C(i)C(j) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} p(x,y) \cos\left[\frac{(2m+1)i\pi}{2N}\right] \cos\left[\frac{(2m+1)j\pi}{2N}\right] \quad (1)$$

Where, $p(x,y) = x,y^{th}$ element of the image represented by the matrix P

N = size of the block

The DCT has become the standard method for image compression typically the image is divided into 8x8 pixel blocks, where each block is transformed into 64 transform coefficients.

Transformation matrix of each block can be calculated by using equation (2).

$$T_{pq} = \begin{cases} \frac{1}{\sqrt{M}} & p = 0, \quad 0 \le q \le M-1 \\ \sqrt{\frac{2}{M}} \cos \frac{\pi(2q+1)p}{2M} & 1 \le p \le M-1, \quad 0 \le q \le M-1 \end{cases} \quad (2)$$

Where,

M = the size of the block that the DCT is done

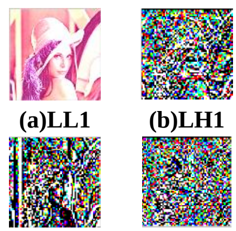
$T_{pq} = p,q^{th}$ element of the image represented by the T .

Because the DCT is designed to work on pixel values ranging from -128 to 127, the original block is “leveled off” by subtracting 128 from each entry of the original image. This result will receive as the following matrix called M matrix which can be calculated by using equation (3).

$$D = T.M.T' \quad (3)$$

4. Discrete Wavelet Transform

Wavelets are special functions which, in a form analogous to sines and cosines in Fourier analysis, are used as basal functions for representing signals. For 2-D images, applying DWT corresponds to processing the image by 2-D filters in each dimension. The filters divide the input image into four non-overlapping multi-resolution sub-bands LL1, LH1, HL1 and HH1. The sub-band LL1 represents the coarse-scale DWT coefficients while the sub -bands LH1, HL1 and HH1 represent the fine scale of DWT coefficients. To obtain the next coarser scale of wavelet coefficients, the sub-band LL1 is further processed until some final scale N is reached. When N is reached we will have 3N+1 sub-bands consisting of the multi-resolution sub-bands LLN and LHx, HLx and HHx where x ranges from 1 until N[9]. Figure 1 shows the DWT decomposition of level 1.



(a)LL1 (b)LH1 (c)HL1 (d) HH1

Figure 1. Wavelet decomposition of level 1

5. Watermark Embedding and Extracting Algorithms for DCT and DWT

On-line handwritten signature is used as the watermark in embedding process. The algorithms of embedding watermark and extracting watermark for DCT and DWT are described in 5.1, 5.2, 5.3 and 6.4.

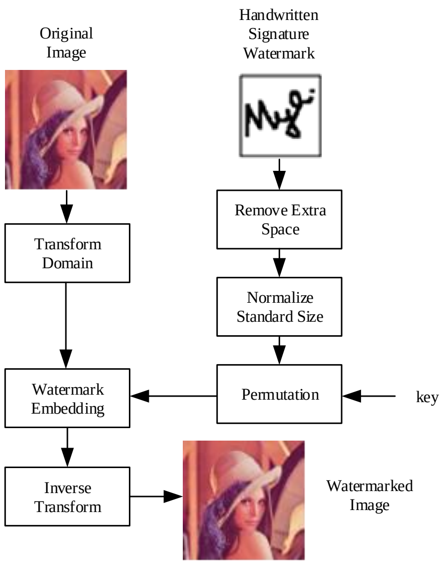


Figure 2. Watermark embedding process

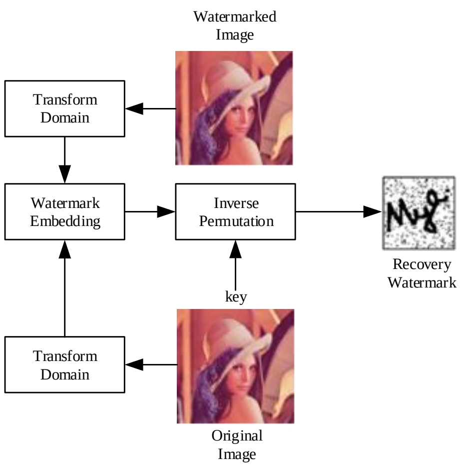


Figure 3. Watermark extracting process

5.1 Watermark Embedding Algorithms for DCT

The watermark embedding algorithm is described as follows.

Step 1: Read original image.

Step 2: The blue channel of original image (I) is performed by Discrete Cosine Transform (DCT).

Step 3: Create online handwritten signature (watermark) by using G-Pen F350 tablet encodes the signature.

Step 4: Convert online handwritten signature to bitmap image (black and white) and rescale to standard size (64x64).

Step 5: for better security and more robustness, the watermark is permutated by using Gaussian distribution and symmetric key.

Step 6: Watermarked image is embedded in the mid band of the above blue channel DCT transformed according to the below equation 4.

$$I'(i, j) = tI(i, j) + s * \left(1 - w(i, j)\right) * M \qquad (4)$$

where, I' is watermarked, tI is DCT transformed coefficient of original image, s is signal strength, w is watermark bit and M is watermark energy.

Step 7: To achieve watermarked image, I' is inverse transformed with IDCT.

Step 8: Evaluate the watermarked image quality by Peak Signal to Noise Ratio (PSNR).

5.2 Watermark Extracting Algorithm for DCT

Step 1: Read watermarked image.

Step 2: Transform the blue channel of the watermarked image to frequency domain with DCT.

Step 3: Watermark image (signature) is extracted from watermarked image by using equation 5.

$$w'(i, j) = I'(i, j) - tI(i, j) \qquad (5)$$

where, I' is watermarked, tI is DCT transformed coefficient of original image and w' is watermark bit.

Step 4: After the subtraction, embedded watermark energy pixels are remained in the form of greater than 0's. They are changed into 0's and others are 1's to recovered permutated watermark.

Step 5: To recover Watermark image (online signature), the recovery permutated watermark is performed inverse Gaussian permutation using symmetric key.

Step 6: Evaluate the watermark image quality by Normal Correlation (NC).

5.3 Watermark Embedding Algorithms for DWT

The watermark embedding and extraction algorithms are nearly the same as the above DCT algorithms. The embedding algorithm of DWT is described as follows.

Step 1: Read original image.

Step 2: The blue channel of the original image is transformed with Discrete Wavelet Transform (DWT).

Step 3: Create online handwritten signature (watermark) by using G-Pen F350 tablet encodes the signature.

Step 4: Convert online handwritten signature to bitmap image (black and white) and rescale to standard size (64x64).

Step 5: To be more secure and robustness, the watermark is permutated by using Gaussian distribution and symmetric key**.**

Step 6: Watermarked image is embedded on LH1 and HL1 accordance with the online signature by using equation 4.

Step 7: To show watermarked image, I' is transformed with IDWT.

Step 8: Evaluate the watermarked image quality by Peak Signal to Noise Ratio (PSNR).

5.4 Watermark Extracting Algorithm for DWT

Step 1: Read watermarked image.

Step 2: Transform the watermarked image to frequency domain with DWT.

Step 3: Watermark image (signature) is extracted from watermarked image by using equation 5. The extraction process is performed on both LH1 and HL1.

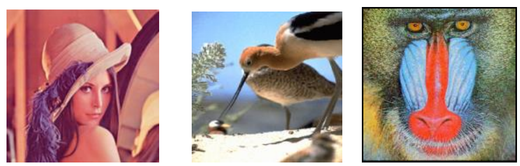
Step 4: The two extracted results from LH1 and HL1 are performed AND operation and then the final results are changed into 1's and 0's by setting their around values. The 1's and 0's matrix (final result) is recovery permutated watermark.

Step 5: To recover Watermark image (online signature), the recovery permutated watermark is performed inverse Gaussian permutation using symmetric key.

Step 6: Evaluate the watermark image quality by Normal Correlation (NC).

6. Experimental Setting and Results

In our experiments, five 256×256 pixels color images having various characteristics, 'Lena', 'Bird', 'Baboon', 'Pepper' and 'Airplane' were used as original testing images. A handwritten signature with various sizes was used as a watermark. Four original testing images and the watermark signature are illustrated in Figure 4 and 5.



(a) (b) (c)

(d) (e)

Figure 4. Original testing images (a) *Lena* (b)*Bird*(c) *Baboon* (d) *Pepper (e) Airplane*

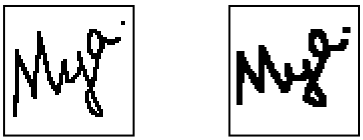


Figure 5. Watermark handwritten signature

The performance of DCT and DWT transformed based watermarking algorithms using different original cover host image and various sizes of online signatures are used in this paper.

Imperceptibility means that the perceived quality of the host image should not be distorted by the presence of the watermark. As a measure of the quality of a watermarked image, the peak signal to noise ratio (PSNR) is typically used. PSNR in decibels (dB) is given below in equation (6). The retrieval performance is determined by the quality of recovery watermark comparing with original watermark image. To measure the retrieval performance, Normal Correlation (NC) is evaluated. The following equation (7) is for the Normal Correlation (NC).

$$PSNR\,(\mathrm{dB}) = 20\log_{10}\frac{255\sqrt{3MN}}{\sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N}(B'(i,j)-B(i,j))^2}} \quad (6)$$

$$NC = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} w(i,j)w'(i,j)}{\sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N} w(i,j)^2}\sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N} w'(i,j)^2}} \quad (7)$$

From these equations, M and N are the numbers of row and column of the images; B' and B are watermarked and original cover image, $w(i,j)$ and $w'(i,j)$ are the original watermark bit and the retrieved watermark bit at coordinate (i,j).

Table 1 shows the PSNR and NC values of the DCT and DWT watermarking algorithms according to their comparisons on the various testing images described as above. The figure 6 shows the retrieval performance comparison of the two transform based algorithms. The NC values in the figure 6 are measured with different images at the same PSNRs. The table 1 and figure 6 results clearly show that the retrieval performance of DWT based watermarking is outperformed than DCT based in every image at nearly the same PSNRs.

Table 1. PSNR values of test images

Performance Comparison between DCT and DWT				
	DCT		DWT	
Image	PSNR	NC	PSNR	NC
Airplane	63.0824	0.952791	63.0283	0.9720453
Baboon	53.3825	0.944417	53.3255	0.957052
Pepper	57.2551	0.944574	57.3001	0.96535
Bird	60.1082	0.951309	60.1808	0.976849
Lena	56.4891	0.960781	56.4571	0.966635

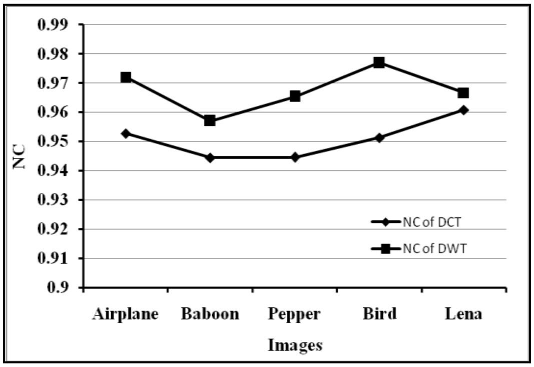


Figure 6. Retrieval performance comparison of DCT and DWT

(a) (b) (c)

Figure 7. (a)original image, (b)watermarked image at PSNR=63.0824 and (c) recovery watermark of DCT

(a) (b) (c)

Figure 8. (a)original image, (b)watermarked image at PSNR=63.0283 and (c) recovery watermark of DWT

The above figure 7 and figure 8 illustrate the output result images of embedding and extracting on DCT and DWT domain.

To measure the robustness of the two methods, some attacks are used with various ranges. The following table shows the robustness results according to different attacks.

Table 2. ***NC*** **values obtained from various attacks.**

No	Type of attack	strength	NC of DCT	NC of DWT
1	JPEG	90%	0.652074	0.680714
2	Blurring	20% of image pixel	0.671538	0.715115
3	Brightness	30%	0.805589	0.707572
4	Salt & Pepper	0.03 density	0.629932	0.652999
5	Cropping	50%	0.645372	0.675625

According to the result of table 2, the robustness of the two proposed methods is so weak in all attacks. However, it can tell whether there is modified or not. In some of attacks such as brightness, watermark can be read with heavy noises.

According to the result in table 2, in almost of attacks, it can be seen that DWT is better than DCT.

7. Conclusion and Future Work

Digital watermarking became a key technology for protecting copyrights and authentication. We presented performance analysis of watermark embedding and extraction based on DCT and DWT and different standard images. On-line handwritten signature of different user for dynamic visual watermarking is proposed in this paper.

In studying image authentication and transformed based watermarking techniques, the proposed paper was written. The paper is just focused and interested on the performance comparison of DCT and DWT with the same embedding and extraction algorithms. This proposed method is so weak in robustness and non blind. In the future, we will try to improve the human imperceptibility and retrieval performance by using Neutral Net based approach without the use of original image.

References

[1] S.J. Lee, S.H. Jung, "A servey of watermarking techniques applied to multimedia," Proc. of ISIE 2001, Pusan, South Korea, vol. 1, pp. 272-277, June 2001.

[2] I.J. Cox, M.L. Miller, and J.A. Bloom, "Digital wateramrking and Steganography," Morgan Kaufmann Publishers, 2002.

[3] YanqunZhang, "Digital Watermarking Technology: A Review" ,2009 ETP International Conference on Future Computer and Communication

[4] Houtan Haddad Larijani and Gholamali Rezai Rad "A New Spatial Domain Algorithm for gray scale images watermarking" Proceedings of the International Conference on Computer and Communication Engineering 2008 May 13-15, 2008 Kuala Lumpur, Malaysia

[5] Munesh Chandra "A DWT Domain Visible Watermarking Techniques for Digital Images"2010 International Conference on Electronics and Information Engineering (ICEIE 2010)

[6] Ibrahim Nasir, Ying Weng, Jianmin Jiang "Novel Multiple Spatial Watermarking Technique in Color Images" Fifth International Conference on Information Technology: New Generations

[7] Mandeep Singh Saini, Venkata Kranthi B and Gursharanjeet Singh Kalra "Comparative Analysis of Digital Image Watermarking Techniques in Frequency Domain using MATLAB SIMULINK" International Journal of Engineering Research and Applications (IJERA), Vol.2, Issue 4, May-Jun 2012, pp.1136-1141

[8] Mei Jiansheng, Li Sukang and Tan Xiaomei "A Digital Watermarking Algorithm Based on DCT and DWT" Proceeding of the 2009 International Symposium on Web Information Systems and Applications (WISA'09) Nanchang, P.R.China, May 22-24, 2009, pp.104-107

[9] Chirag Sharma, Deepak Prashar, "DWT Based Robust Technique of Watermarking Applied on Digital Images", International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-2, Issue-2, May 2012.

[10] A.M.Kothari, A.C.Suthar, R.S.Gajre, "Performance Analysis of Digital Image Watermarking Technique–Combined DWT – DCT over individual DWT", International Journal of Advanced Engineering & Applications, Jan. 2010.