International Conference on Smart Electronic Systems - 2016
KLE Society's Dr M S Sheshgiri College of Engineering & Technology, Belagavi

International Journal of Technology and Science, ISSN (Online) 2350-1111, (Print) 2350-1103 Volume 3, Issue 4, 2016 pp. 10-13

A Joint DWT-DCT Based Blind Digital Watermarking for Copyright Protection

Sukanti B. Mardolkar [1], Nayana Shenvi[2]
[1] Goa College of Engineering /ETC Dept., Goa, India
sbmardolkar@gmail.com
[2] Goa college of Engineering/ETC Dept., Goa, India
nayana@gec.ac.in

Abstract— ***In this paper a digital watermarking algorithm based on joint DWT-DCT transformation is proposed. The watermark embedding is carried out by using the low frequency coefficients of 4×4 DCT block. Watermarked image is further processed by using weighted correction in spatial domain to increase imperceptibility. The host image is first decomposed to two levels of DWT. The DCT of the chosen DWT sub-band is then computed. Binary watermark is scrambled with Arnold transform which increases robustness. PN sequences are used for embedding the watermark. The proposed watermarking algorithm is blind since it does not require original host image for watermark extraction. The experimental results show that the proposed method has achieved high level of imperceptibility and is robust to most of the common signal processing and geometric attacks.***

Index Terms—Arnold Transform, Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), Digital Image Watermarking, PSNR, Robustness.

I. Introduction

Widespread use of internet technology has made a large amount of multimedia data such as images, audio and video available to the users. In addition to this, several advanced digital multimedia tools are available which can be used to copy and manipulate the data. This has created a threat to the copyright protection of multimedia data. Digital watermarking tries to solve this problem.

Watermarking is a process that hides some information such as a logo into the original image. This hidden information is called a watermark. The watermark information can be copyright information, authentication information or controlling information so as to determine the copyright owner of the digital works, certify the authenticity and integrity of multimedia works, control copying according to the embedded control information, achieve the purpose of copyright protection [1].To serve its intended purpose, the two main requirements an effective watermarking algorithm should meet are perceptual transparency and robustness. To get high robustness the watermark needs to be embedded into perceptually significant coefficients of the image, but this reduces perceptual transparency. To increase the perceptual transparency the watermark needs to be embedded into higher frequency coefficients. However this eventually affects the robustness. Thus, two essential prerequisites for a powerful watermarking scheme, robustness and perceptual transparency conflict with each other [2].

Watermarking techniques can be classified mainly as spatial domain and frequency domain techniques. Frequency domain techniques provide better robustness and imperceptibility. Frequency domain techniques mostly employ Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT).However DWT has been used in digital image watermarking more frequently due to its excellent spatial localization and multi-resolution characteristics, which are similar to the theoretical models of the human visual system [3].The performance of the DWT based watermarking algorithm can be further improved by using a combination of the two transforms that is DWT-DCT [2-5].

II. The Watermark Embedding

The host image of size 512×512 is first decomposed by two levels of DWT and sub-band HL_2 is selected. The sub-band HL_2 is divided into 1024 blocks each of size 4×4. DCT is applied to each of the 4×4 block. The binary watermark of size 32×32 is scrambled using Arnold transform. The watermark embedding is performed on low frequency coefficients of 4×4 block DCT. Fig.1 shows the block diagram for watermark embedding process. All the required steps are as follows:

Step1: Using DWT decompose the host image of size 512×512 into four non- overlapping multi-resolution sub-bands. This result in sub-bands LL_1, HL_1, LH_1, and HH_1 having size 256×256.

Step2: Select sub-band HL_1 and using DWT decompose it to get four smaller sub-bands each of size 128×128. Fig. 2 shows the two-level decomposition of an image. Now select HL_2 sub-band for embedding the watermark.

Step3: After choosing sub-band HL2 divide it into 1024 blocks such that each of the blocks is of size 4x4.

Step4: Transform each of the 4×4 block from spatial domain to frequency domain by applying DCT.

Step5: Scramble the watermark using Arnold transform which is given as:

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & 2 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} mod\ N \ ;\ x, y \in \{0,1,2,\dots,N-1\} \qquad (1)$$

Where, x and y are the original watermark pixel coordinate, and x' and y' are the transformed watermark pixels coordinate.

After application of the Arnold transform the watermark turns to a scrambled watermark. This scrambled watermark is embedded into the host image.

International Journal of Technology and Science, ISSN (Online) 2350-1111, (Print) 2350-1103 Volume 3, Issue 4, 2016 pp. 10-13

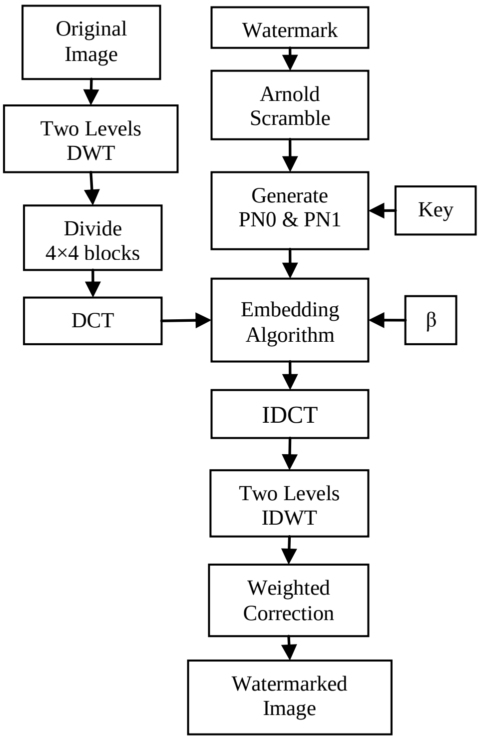


Fig.1 Watermark embedding procedure

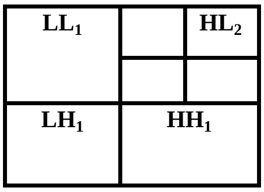


Fig.2 Decomposition of image with two levels DWT

Step6: Use a key and generate two uncorrelated pseudorandom sequences PN1 and PN0.
Step7: Using the gain factor 'β' embed PN1 and PN0 into the DCT transformed 4×4 blocks of the selected DWT coefficient set (HL_2) of the host image.
Only low frequency coefficients of each DCT block as shown in Fig.3 are used for watermark embedding.

If we denote Z as the matrix with its elements as the low frequency coefficients of the 4×4 DCT transformed block, then embedding is carried out as per the equations (2) and (3).

$$Z' = Z + (\beta \times PN0) \quad ; \text{if watermark bit}=0 \qquad (2)$$
$$Z' = Z + (\beta \times PN1) \quad ; \text{if watermark bit}=1 \qquad (3)$$

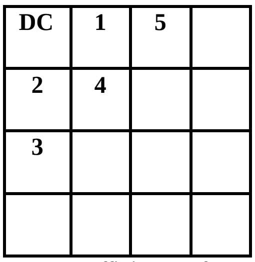


Fig. 3 Low frequency coefficients of a 4×4 DCT block that are used for watermarking

Step8: Perform the IDCT on each block.
Step9: Perform the IDWT on the DCT transformed image to get the watermarked host image in spatial domain.
Step10: Process the watermarked image using weighted correction. This results in increased imperceptibility.

III. The Watermark Extraction

The watermark extraction process repeats few steps from watermark embedding process after pre-filtering operation. Pre-filtering is done to increase the robustness. The block diagram of watermark extraction is shown in Fig. 4. All the required steps are as follows.
Step1: Perform pre-filtering operation on watermarked image.
Step2 Using DWT decompose the watermarked image into four non- overlapping multi-resolution sub-bands. This results in sub-bands LL_1, HL_1, LH_1, and HH_1.
Step3: Again using DWT further decompose the sub-band HL_1 to get four smaller sub-bands.
Step4: Next divide sub-band HL2 into 4 × 4 blocks.
Step5: Perform DCT on each 4 × 4 block.
Step6: With the help of the same key that was used in the watermark embedding procedure regenerate the two pseudorandom sequences PN0 and PN1.
Step7: Beginning with the first block till the last block, calculate correlation between the low-band coefficients of the block and the two generated pseudorandom sequences. If the correlation of the low-band coefficients with the PN0 is higher as compared to the correlation with PN1, then the extracted watermark bit is taken as '0', otherwise the extracted watermark bit is taken as a '1'.

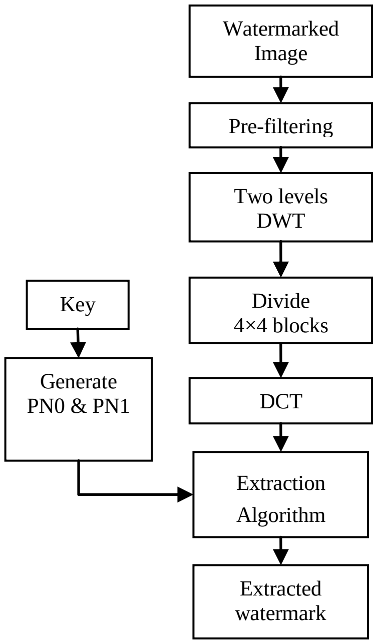


Fig.4 Watermark extraction procedure

Step8: Using the watermark bits that are extracted using the previous step, reconstruct the scrambled watermark.

Step9: Finally scramble the reconstructed watermark with Arnold transform with the same key times. This is the final extracted watermark.

IV. Performance Evaluation

The proposed algorithm is tested using several standard test images. Fig.6 shows the three test images used as host images for the experiment. The selected host images are of size 512×512. The binary watermark is of size 32×32.We used imperceptibility and robustness to evaluate the watermarking algorithm.

Imperceptibility: 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.

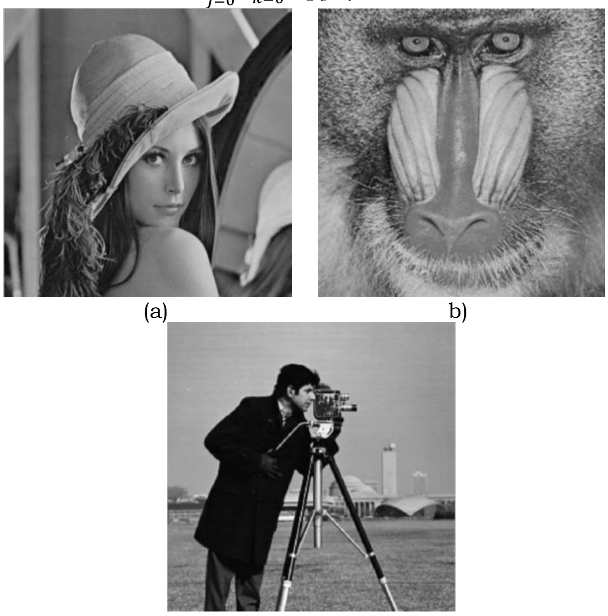
$$\mathrm{PSNR(dB)} = 10\log_{10}\left(\frac{255^2}{MSE}\right) \quad (4)$$

where ,

$$\mathrm{MSE} = \frac{\sum_{i=0}^{N-1}\sum_{j=0}^{N-1}\left[I_1(i,j)-I'_2(i,j)\right]^2}{N\times N} \quad (5)$$

Robustness: Robustness is a measure of the immunity of the watermark against attempt to remove it by different types of attacks. Here similarity between the original watermark and the extracted watermark from the attacked image is measured by using the Normalized Correlation (NC) factor.

$$NC = \frac{\sum_{j=0}^{J-1}\sum_{k=0}^{K-1} W_1(j,k)W_2(j,k)}{\sum_{j=0}^{J-1}\sum_{k=0}^{K-1} W_1(j,k)^2} \quad (6)$$



(a) b)

(c)

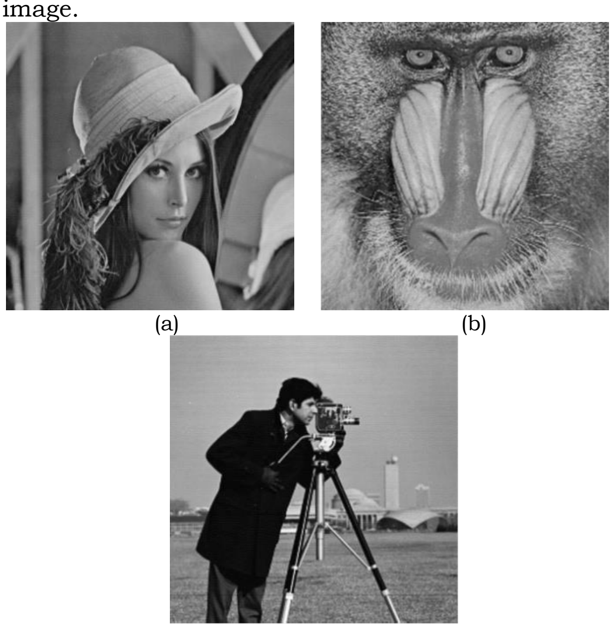
Fig.6.Original Test images (a) Lena, (b) Mandrill, and (c) Cameraman

The presented method is implemented using MATLAB. Original watermark with text "ECI" and Arnold scrambled binary watermark with different scrambling keys are shown in Fig.7. The three watermarked images Lena, Mandrill and Cameraman without any attacks are shown in Fig.8. There are no visible distortions in the watermarked images and therefore the algorithm provides high level of imperceptibility. Fig.9.shows the watermarks extracted from the three watermarked images.

(a) (b) (c) (d)

Fig.7 Arnold scrambled binary watermark (a) original watermark, (b) watermark scrambled with key=1, (c) watermark scrambled with key=5, and (d) watermark scrambled with key=8.

In order to get the measure of the robustness of the presented algorithm, we implemented several image processing and geometric attacks such as JPEG compression, salt & pepper noise, speckle noise, gaussian noise, median filtering, average filtering, and image cropping on the watermarked image.



(a) (b)

(c)

Fig.8.Watermarked test images (a) Lena, (b) Mandrill, and (c) Cameraman

(a) (b) (c)

Fig.9. Extracted watermarks (without attack) from (a) Watermarked Lena, (b) Watermarked Mandrill, and (c) Watermarked Cameraman

In this experiment test image Lena is used to demonstrate the results of the watermarking algorithm against different types of attacks. The attacked watermarked images with different attacks are shown in Fig.10. Similarly, extracted watermarks from attacked watermarked images are shown in Fig.11. The experimental results for various attacks implemented on watermarked Lena are given in Table 1. Watermarked image has a PSNR as high as 37.8051 dB when it is not attacked by any signal processing or geometric attacks. This high value of PSNR means that the watermark will not be detected by Human Visual System (HVS). For most of the implemented attacks the watermark is extracted with NC values higher than 0.9 which indicates that the algorithm successfully withstands the watermark attacks.

Fig.10 Attacked watermarked images (a) JPEG compression (Q=50), (b) Salt & pepper noise (var=0.03), (c) Gaussian noise (var=0.002), (d) Speckle noise (var=0.02), (e) Median filtering, (f) Average filtering and (g) Image cropping (64×64)

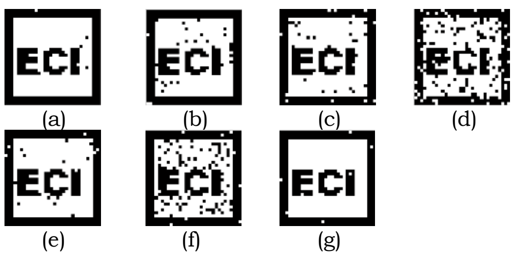


Fig.11 Extracted watermarks from attacked watermarked images (a) JPEG compression, (b) Salt & pepper noise, (c) Gaussian noise, (d) Speckle noise, (e) Median filtering, (f) Average filtering and (g) Image cropping

Table 1. PSNR and NC values for watermarked Lena under different attacks

Attack	Parameters		PSNR (dB)	NC
No attack			37.8051	1
JPEG Compr-ession	Q= 90		37.4306	1
	Q= 70		36.0213	1
	Q= 50		32.3917	0.9862
Salt & pepper noise	variance =0.01		24.6617	1
	variance =0.02		21.9537	0.9687
	variance =0.03		20.2538	0.9420
Gaussian noise	mean = 0	variance = 0.002	26.7143	0.9592
Speckle noise	Variance= 0.01		26.3359	0.9020
	Variance= 0.02		23.1514	0.7559
Median filtering	3×3		34.6521	0.9608
Average filtering	3×3		32.2948	0.8242
Image cropping	32×32		27.5620	0.9941
	64×64		22.7767	0.9863

V. Conclusions

Watermarked image has a PSNR as high as 37.8051 dB under no attack case, which indicates that the proposed algorithm has achieved high imperceptibility. With several types of signal processing and geometric attacks the watermarking scheme can successfully recover the watermark with high values of NC. It is evident from the results that the proposed algorithm has utilized the benefits of the two most popular and effective transforms DWT and DCT to achieve high level of imperceptibility and robustness. Thus the proposed algorithm can be used successfully to provide copyright protection.

References

[1]Jiang Xuehua. "Digital Watermarking and its Application in Image Copyright Protection", 2010 International Conference on Intelligent Computation Technology and Automation.

[2]Saied Amirgholipour Kasmani, Ahmadreza Naghsh-Nilchi, "A New Robust Digital Image Watermarking Technique Based On Joint DWT-DCT Transformation", IEEE 3rd International Conference on Convergence and Hybrid Information Technology Vol. 2 ,year 2008, pages 539-544.

[3] Ali Al Haj, "Combined DWT-DCT Digital Image Watermarking", Journal of Computer Science 3(9):740-746,ISSN 1549-3636, year 2007.

[4] Akter Afroja, Nur-E-Tajnina, and Muhammad Ahsan Ullah. "Digital image watermarking based on DWT-DCT: Evaluate for a new embedding algorithm", 2014 International Conference on Informatics Electronics & Vision (ICIEV).

[5] Deb K., Al-Seraj M. S., Hoque M. M.,Sarkar M. I. H., "Combined DWT-DCT Based Digital Image Watermarking Technique for Copyright Protection", IEEE 7th International Conference on Electrical and Computer Engineering, 20-22 December, year 2012, pages 458-461.