ISSN: 0976-9102(ONLINE)
DOI: 10.21917/ijivp.2013.0095

A WAVELET TRANSFORM BASED WATERMARKING ALGORITHM FOR PROTECTING COPYRIGHTS OF DIGITAL IMAGES

Divya A[1] and Priya H. K[2]
[1]*Depatment of Electronics and Communication Engineering, Dr. Ambedkar Institute of Technology, India*
E-mail: divyavsagar24@gmail.com
[2]*Department of Telecommunication Engineering, Dr. Ambedkar Institute of Technology, India*
E-mail: priya_hk@yahoo.com

Abstract

This paper proposes an algorithm of Digital Watermarking based on Biorthogonal Wavelet Transform. Digital Watermarking is a technique to protect the copyright of the multimedia data. The position of the watermark can be detected without using the original image by utilizing the correlation between the neighbours of wave co-efficient. The strength of Digital watermark is obtained according to the edge intensities resulting in good robust and Imperceptible. Results show that the proposed watermark algorithm is invisible and has good robustness against common image processing operations.

Keywords:

Digital Watermark, Biorthogonal Wavelet Transform, Correlation

1. INTRODUCTION

Now-a-days, a huge amount of Digital works is circuiting through all over the world by means of World Wide Web. The rapid development of Digitized Multimedia information on the Internet is exposed and can be easily corrupted [1]. The need for intellectual copyrights protection of digital works has developed into a serious problem. Since commercial interests seek to use the digital networks to offer digital media for profit and have a strong interest in protecting the ownership rights. Digital Watermarking technology has been attracted high attention for intellectual property rights protection to image by hiding appropriate information in original image to declare right full ownership.

Digital Watermarking Algorithm can be divided into the Spatial Domain Algorithm and the Transform Domain Algorithm. The Spatial Domain method is of high capacity, easy to realize with low computational cost. The loaded Watermark in spatial domain method [2] is fragile so that it can be easily destroyed by some image processing operations such as noise addition, rotation, cropping scaling, resizing and compression. In the Transform Domain the watermark is inserted into transformed co-efficient of image resulting in high information hiding capacity and more robustness against Watermark attacks.

Watermarking in Transform Domain Algorithm is more suitable for the Digital works copyright protection [3] compare to Spatial Domain because information can be spread out to entire image. Transform Domain scheme includes Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT).

Embedding Watermark in host image using DFT is suffering from the JPEG attacks. Although embedding Watermark in host image by DCT is robust compared to DFT but DWT is more advantageous over the DCT. DWT has good time-frequency local characteristics i.e., it provides both space and frequency localization with different resolution levels and facilitates to combine with Human Visual System (HVS) thus, attaining a good trade-off between Robustness and Imperceptibility.

2. DIGITAL IMAGE WATERMARKING TECHNIQUES IN SPATIAL AS WELL AS TRANSFORM DOMAIN

A complete overview of Digital Image watermarking techniques in Spatial as well as transform domain is provided in [4]. The study focuses on quality factors essential for good quality watermarking, Performance evaluation metrics (PSNR and Correlation Factors) and possible attacks. Overview of several methods with spatial and Transform Domain watermarking is done with detail mathematical formulae, their implementations, strengths and weaknesses. The generalized algorithms are presented for DWT, CDMA based, DCT-DWT combined approach. The Ridgelet Transform is also introduced. Ridgelets are next generation wavelets and they are best options for line singularities. Ridgelets have high coding performance for 1D wavelet transform. Actually Ridgelet transform is based on radon transform and 1D wavelet transform. It can rotate the picture by operation in ridge let domain. Comparative results of Digital Image Watermarking using LSB, DCT and DWT are also presented. The paper recommends DWT based techniques for achieving Robustness in Digital Image Watermarking. The Transform domain watermarking techniques are recommended to achieve robustness. As per ISO Norms, JPEG2000 has replaced DCT by DWT. Hence more researchers are focusing on DWT.

2.1 ALGORITHM OF DIGITAL WATERMARKING BASED ON DISCRETE COSINE TRANSFORM (DCT) AND DISCRETE WAVELET TRANSFORM (DWT)

An algorithm of digital watermarking based on Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) is introduced [5]. According to the characters of human vision, in this algorithm, the information of digital watermarking this has been discrete Cosine transformed, is put into the high frequency band of the image which has been wavelet transformed and then distils the digital watermarking with the help of the original image and the watermarking image. The simulation results show that this algorithm is invisible and has good robustness for some common image processing operations.

3. THE DISCRETE WAVELET TRANSFORM OF DIGITAL IMAGE

The wavelet Transform is a basic function that satisfies certain mathematical requirements and using the same function by expanding and shifting to approach the original signal. The wavelet coefficients carry both the time and frequency information therefore having good local characteristics in Time Domain and Frequency Domain which facilitates to combine with human vision characteristics.

A digital image is decomposed into four frequency districts in which there is a low frequency subband (LL) and three high frequency subbands (LH, H1, HH). For better diffused and stronger watermark intensities more level decomposition of the image is done by using wavelet transform. The original image can be decomposed into frequency districts and sublevel frequency districts information. By doing this the original image can be decomposed for *n* level wavelet transformation. The low frequency information image is close to the original image. In this paper we make use of three level wavelet decomposition i.e., low frequency subband (LL3), Horizontal high frequency subbands (LH3, LH2, LH1), Vertical high frequency subband (HL3, HL2, HL1) and Diagonal high frequency subband (HH3, HH2, HH1) and is shown in the below Fig.1.

<table>
<tr><td>LL3</td><td>HL3</td><td rowspan="2">HL2</td><td rowspan="3">HL1</td></tr>
<tr><td>LH3</td><td>HH3</td></tr>
<tr><td colspan="2">LH2</td><td>HH2</td></tr>
<tr><td colspan="3">LH1</td><td>HH1</td></tr>
</table>

Fig.1. Three-level wavelet decomposition

According to the HVS characteristics [6], our human eye is more sensitive to the change of smooth district edge of the image compare to change of edges, streaks and profiles. Therefore it is hard to embed the watermark signal into the high amplitude coefficient of high-frequency band of the image.

Wavelets can be of orthogonal or biorthogonal. Most of the watermarking technologies make use of biorthogonal wavelet transform because it has some favourable and more advantageous properties over the orthogonal wavelet transform. The biorthogonal transform is an invertible transform and has a property of perfect reconstruction and smoothness. It is having high superiority in image processing compare to orthogonal wavelet transform because of it balances both orthogonality and symmetry property. In this algorithm we use Daubechies biorthogonal wavelet which is most suitable for the wavelets applicator in the digital watermark and it is recommended in JPEG2000 standard.

4. PROPOSED WATERMARKING ALGORITHM

The description about the watermarking technique we proposed uses Biorthogonal wavelets includes the watermark pre-processing, the watermark embedding process and the extraction process.

4.1 THE WATERMARK PRE-PROCESSING

Arnold Transform is applied to the binary image i.e., watermarking pre-treatment is done and randomized image is embedded as watermarking to produce watermarked image. Again while detecting the watermark; Arnold transform can be used to make the randomized watermarking return to its original state with periodicity. The Arnold transformation enhances the security of the algorithm and also can make watermark more robust and invisible against some cutting operations. In order to reduce the correlation existed in the watermark Arnold transformation is adopted for scrambling of watermark in advance. The Arnold transform that is applied to every pixel in the image is given by the formula in a matrix notation and is shown in Eq.(1).

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & 2 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} (\bmod N) \qquad (1)$$

where, N is the order of the image matrix, (x, y) are the pixel coordinates from original image and (x', y') are the corresponding results after Arnold transform.

In this algorithm, the gray-level image with size of 512×512 "Lena" image is used as host to embed the watermark and another binary image with size of 64×64 "text" is used as the watermark. The scrambling time is used as an encryption key1. The original watermark and the scrambled watermark are shown in Fig.2.

(a) (b)

Fig.2. (a) Original watermark (b) Scrambled watermark

4.2 THE EMBEDDING PROCESS

In our proposed embedding process, we make use of localized decomposition. Embedding a watermark in the low frequency components results in declined visual quality of the image and hence affects the watermark's invisibility. And if embedding a watermark in the high frequency components lead to good invisibility but robustness of the watermark will be affected. In order to achieve good balance between robustness and invisibility we go for embedding a watermark in second level high frequency subbands (HL2, LH2, HH2) or the intermediate frequency subband. Larger wavelet coefficients are used to load watermark bit to obtain large intensity watermark.

To enhance the robustness against some image processing operation, important edge coefficient is selected to embed the watermark. The way of embedding the watermark is as shown in Fig.3.

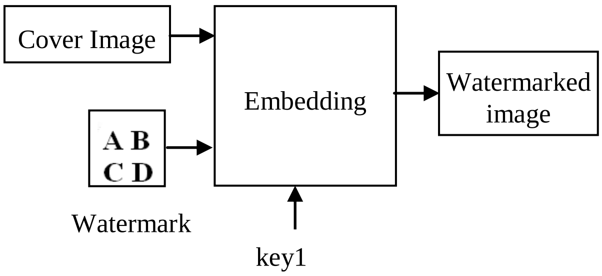


Fig.3. Watermark Embedding System

According to the proposed algorithm, the absolute coefficients are selected in the same location of the third level high frequency subbands (HL3, LH3 and HH3) are added together and the important edge positions are selected with larger *N* value. The second level high frequency subbands are embedded in the corresponding positions in the bits in order to avoid the mutual interference introduced during watermark embedding process. By adjusting the relation of the coefficient and the average of its neighbourhood coefficient the watermark can be embedded effectively and the average of four neighbourhood used in this algorithm is given by the Eq.(2).

$$Mean_{2X,2Y} = \left(\begin{array}{l} D_2(2_X - 1, 2_Y) + D_2(2_X + 1, 2_Y) \\ + D_2(2_X, 2_Y - 1) + D_2(2_X, 2_Y + 1) \end{array} \right) \Big/ 4 \quad (2)$$

The watermark intensity can be located at the wavelet coefficient in (*x*, *y*) in the third level high frequency sub band is embedded as a part of the watermark intensity. The cover image and the embedded image is as shown in the below Fig.4, where there is no differences identified by eye observation.

(a) (b)

Fig.4. (a) Cover Image (b) Embedded Watermark Image

4.3 THE DIGITAL WATERMARK EXTRACTION PROCESS

When extracting the watermark from the host image in this algorithm, the embedded watermark image is first decomposed by three level wavelet transform and then the watermark embedded positions are finding out by insertion of key2, where key2 is the location of the selected coefficients. The watermark extraction process is as shown in the below Fig.5.

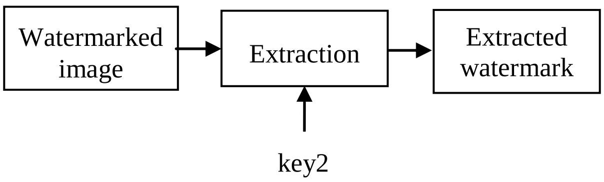


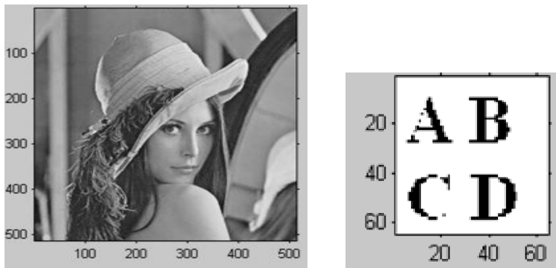
Fig.5. Watermark Extraction System

Here the original image is not required for detecting the watermark. The watermark extracted according to the following Eq.(3) given below,

$$W_i = \begin{cases} 1 & \text{if } D_{2X,2Y} > Mean_{2X,2Y} \\ 0 & \text{if } D_{2X,2Y} < Mean_{2X,2Y} \end{cases} \quad (3)$$

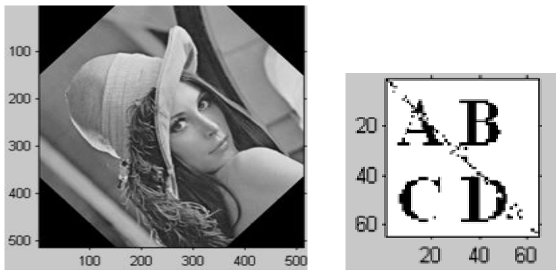
5. EXPERIMENTAL RESULTS

This section provides the proposed watermarking scheme's experimental results and analysis. The proposed watermarking scheme is programmed in Matlab. The technique discussed in the paper effectively embedded the watermark image into the host image and extracted it back from the watermarked. The simulation results, including the watermarked image and extracted watermark under different kinds of signal attack are shown from Fig.6 to Fig.10.



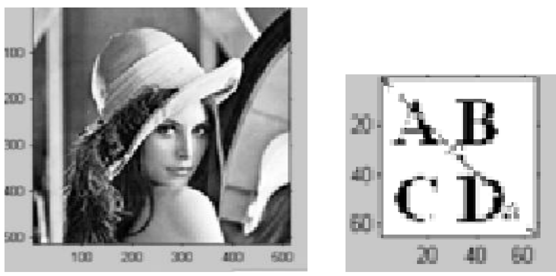
(a) (b)

Fig.6. (a) Original image (b) Watermark



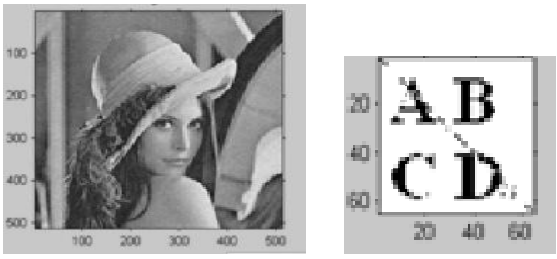
(a) (b)

Fig.7. Result under rotation 45^o



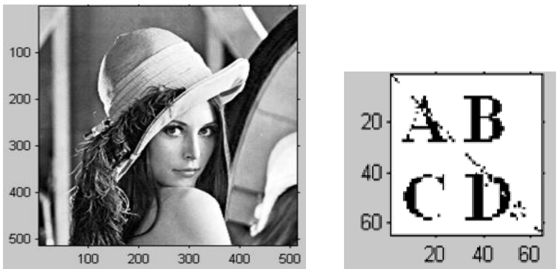
(a) (b)

Fig.8. Result under best contrast



(a) (b)

Fig.9. Result under Gaussian noise



(a) (b)

Fig.10. Result under Hist Equalise

The NC values and PSNR values of the processing for previously published results [5] and biorthogonal wavelet based watermarking algorithm are shown in Table.1.

Table.1.Comparison results for PSNR and NC values

	Attacks	**PSNR**	**NC**
Previously published results [5]	Filter	35.5801	0.9132
	Noise	28.0851	0.8643
	Compression	31.7749	0.8518
	Cutting	27.3359	0.7089
	Enhancing	32.0763	0.8962
	Rotation	21.5003	0.5034
The proposed Biorthogonal wavelet based watermarking algorithm	Normal (without attack)	20.9385	0.9928
	Rotation 45^o	17.9945	0.9857
	Best Contrast	18.8808	0.9881
	Gaussian Noise	19.4960	0.9901
	Hist Equalise	18.8808	0.9881

From the above table and figures, we can ensure the security and robustness of the embedded watermark against Gaussian noise, Hist equalize, best contrast and rotation cropping. The key, which is used to select blocks in sub-bands for embedding and extracting, makes it difficult to remove the embedded watermark.

6. CONCLUSION

In this paper we proposed a biorthogonal wavelet based watermarking algorithm for copyright protection of the digital images. The simulation results suggest that this watermarking technique keeps the image quality well and as well as robust against some image processing operations such as adding noises like Gaussian noise, speckle noise, rotation operations, hist equalise etc. This algorithm achieve a good balance between robust and invisibility.

REFERENCES

[1] Xia-Mu Niu, Zhe-Ming Lu and Sheng-He Sun, "Digital watermarking of still images with gray-level digital watermarks", *IEEE Transactions on Consumer Electronics*, Vol. 46, No. 1, pp. 137-145, 2000.

[2] A. Reddy and B. N. Chatterji, "A new wavelet based logo watermarking scheme", *Pattern Recognition Letters*, Vol. 26, No. 7, pp. 1019-1027, 2005.

[3] Tang Ning, Zhao Jing-Xiu, "A Way of Robust Digital Watermark Based on Wavelet Transformation", *Network and Computer Security*, No. 11, pp. 44-46, 2009.

[4] Baisa L. Gunjal and R. R. Manthalkar, "An Overview of Transform Domain Robust Digital Image Watermarking Algorithms", *Journal of Emerging Trends in Computing and Information Sciences*, Vol. 2, No. 1, pp. 37-42, 2011.

[5] Mei Jiansheng, Li Sukang and Tan Xiaomei, "A Digital Watermarking Algorithm Based On DCT and DWT", *Proceedings of the International Symposium on Web Information Systems and Applications*, pp. 104-107, 2009.

[6] V. Padmanabha Reddy and Dr. S. Varadarajan, "An Effective Wavelet-Based Watermarking Scheme Using Human Visual System for Protecting Copyrights of Digital Images", *International Journal of Computer and Electrical Engineering*, Vol. 2, No. 1, pp. 1793-8163, 2010.