TELKOMNIKA, Vol.11, No.11, November 2013, pp. 6304~6308
e-ISSN: 2087-278X

In the Network Communication an Improved Algorithm of Image Watermarking based on DWT

KE Yun
Wuhan Yangtze Business University, Wuhan 430065, China
Corresponding author, e-mail: kylinbaby@163.com

Abstract

This paper discussed an improvement algorithm of image digital watermarking based on the discrete wavelet transform (DWT) and singular value decomposition (SVD). In this algorithm, a good characteristic of multiresolution and time-frequency local analysis of discrete wavelet transform combining with image intrinsic algebraic properties of SVD. After decomposing the original host image into four bands, we apply the SVD to watermark image and modify DWT coefficients of the host image with the singular values of the watermark image. Experimental results show that this new image watermarking algorithm has a good imperceptibility of embedded watermark image, security and robust against common attacks such as filtering, geometric, attack, JPEG compression and rotation, etc.

Keywords*: watermark, wavelet transform, singular value decomposition*

1. Introduction

With the rapid development of computer network and communication technology, the copyright protection of digital media has become a task which must be solved urgently.In order to solve this problem, people put forward the concept of digital watermarking technology, what its essence is in the multimedia data using the method of signal processing embedded the marked information (watermark) to confirm the data ownership and ensure the data integrity. [1, 2] According to its different loading methods, it can be divided into two types [3] for image watermarking: spatial domain methods and transform domain methods, from comprehensive performance analysis, the transform domain method is more superior. Singular Value Decomposition (Singular Value Decomposition) technique for mathematical features extracted from image provides a relatively simple method. The image singular value decomposition of the matrix has a good stability, its main attributes can be applied to the image watermarking. Even if the carrier image was slightly disturbed, singular value will not change [4]. Based on the stability characteristics of the image singular value decomposition matrix, when the watermarking information is embedded into the matrix, it will not change greatly in the detected image.

In view of this, this paper will combine this two point, proposes a new improvement scheme of image digital watermarking algorithm based on wavelet transform. Experimental results show that this new image watermarking algorithm has a good imperceptibility of embedded watermark image and robust against common attacks.

2. Description of the Improved Digital Watermarking Algorithm

Using matrix A = {aij} M*N to show the grayscale with size M*N, According to the theory of linear algebra, A singular value decomposition is as following [5]:

$$A=U*S*VT. \qquad (1)$$

Here, U and V is M*M,N*N orthogonal unitary matrix respectively; S= diag(σ1,σ2,…,σr) is a M*N nonnegative diagonal matrix, σi(i=1,2,…,r) is the singular values of matrix A, r=main(m,n), S= diag(σ1, σ2, …, σr) satisfied: σ1≥σ2≥…≥σr.

Received June 8, 2013; Revised July 10, 2013; Accepted Jul 22, 2013

The singular value decomposition used in digital image processing has many advantages. First of all, the image singular value of image represent the intrinsic algebraic properties, Its stability is very good, even if the conventional image processing, its singular value will not have a greater change, and help to achieve the watermark invisibility and robustness. Secondly, the size of the matrix with the singular value decomposition transform is uncertain, it can be a square or rectangle.

This section discusses a new digital watermark embedding scheme. The scheme adopts the discrete wavelet transform and singular value decomposition technique. Assuming that A is the host image, W is the watermark information, and both are the gray image, its size were:M*N, M/2*N/2.

2.1. Design of Digital Watermark Embedding Algorithm

The watermarking embedded algorithm is as follows:

(1) A layer of wavelet decomposition of the host image A, A_w^1 stand for a layer of host image of each subband after wavelet decomposition, here w∈{LL, HL, LH, HH}. LL means low frequency sub-band, HL means Low level through vertical high pass sub-band, LH means high level through vertical low pass sub-band, HH means the high frequency sub-band. LL focus on the most energy of image, HL, LH, HH respectively represent the carrier image edge details, vertical horizontal edge details and diagonal edge details.

(2) According to the formula (1) based on singular value decomposition (SVD) of watermark image:

$$W=Uw * Sw * VwT \quad (2)$$

(3) Extracting the diagonal elements of Sw singular matrix, i.e.:

$$L=diag(Sw) \quad (3)$$

(4) The restructuring of the L with the formation of matrix SL;

(5) Bit plane to obtain SL;

(6) Bit plane into the above SL according to the specified dimensions constitute the binary matrix BL;

(7) Combined with the binary matrix BL, the wavelet transform coefficients HL comply with the following algorithm to modify the host image:

if BL(1)=1

then use of HL coefficient is the largest of the first four coefficients to replace the first coefficient of HL

else use of HL coefficient is the minimum of the first four coefficients to replace the first coefficient of HL

(8) Repeat the above seventh steps till all elements are scanning to the BL;

(9) On the watermarked image with discrete wavelet transform, finally get the watermarked host image.

2.2. Design of Digital Watermark Extraction Algorithm

So-called watermark extraction means that from host image containing the watermark information is embedded in watermark. The watermark extraction process is as follows. Do to contain the watermark information of the host image level discrete wavelet transform, expressed in Ww level after wavelet decomposition watermark information of the host image in each subband, which w ∈{LL, the HL and LH, HH}.

Here, now use the following algorithm to obtain two values of the watermark information:

(1) For all HL four tuples according to the following algorithm to modify its value and get the two value watermark image: If the first element of the HL is the largest of 4 elements, so use 1 to replace the first element value; otherwise, use 0 instead of.

(2) The two value image conversion in the plane;

(3) Get the bit plane vector;

(4) The vector of element as the diagonal elements of matrix singular value;

(5) Singular value decomposition of inverse, then can obtain the watermark image.

3. The Analysis of Experimental Results

In this experiment, such as sample 1, the host image and the watermark image is seperatedly shown its size of 8 bits gray image with 512*512 and 8 bit grayscale with 256*256. Select the Haar orthogonal wavelet to proceed a layer wavelet decomposition and reconstruction for the original host image Use the Peak signal to noise ratio (PSNR) as the objective evaluation of the watermark image standard, use the correlation coefficient (NC) as the extracted watermark and the original watermark similarity evaluation criteria. The following calculation formula of correlation coefficient: $NC(W,\overline{W}) = \frac{\sum_{i=1}^{r} W(i)\overline{W}(i)}{\sqrt{\sum_{i=1}^{r} W^{2}(i) \sum_{i=1}^{r} \overline{W}^{2}(i)}}$. Among them, W is the original watermark image singular value, $\overline{W}$ is to extracted the watermark value, and r=min(m,n), where m, n refers to the W's long and wide.

The watermark image is embedded into the host image in the HL subband, when the embedding factor is 0.004, the watermarked image (Figure 2(a) is shown) between the original host image and PSNR value is 38.25, almost no visual difference. Under the not subjected to any attack, the watermark image from each subband extraction constructed as shown Figure 2(b), correlation coefficient NC and the original watermark image was 1.

(a) (b)

Figure 1. (a) The host image and (b) The original watermark image

(a) (b)

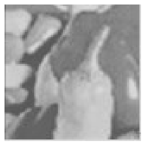
Figure 2. (a) The watermarked image and (b) The extraction watermark image

In order to study the robustness of the algorithm, Host containing the watermark image has specially carried on the mean filter and gaussian filter and circular area average filtering and attacks such as JPEG compression (50:1). Respectively from three different attacked the watermark image extracted watermark image accordingly, Compare them with the original watermarking images. Drawings as shown in Figure 3, Figure 4, Figure 5. Found from the figure. Although extracted watermark image has had the serious degradation, but is still discernibled.

(a) The attacked watermarked image (b) The extraction watermark image

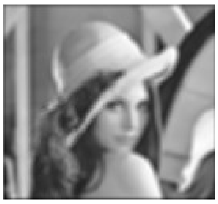
Figure 3. Mean Filtering Attack (4*4windows)

(a) The attacked watermarked image



(b) The extraction watermark image

Figure 4. Gauss Filtering Attack (8*8windows)



(a) The attacked watermarked image

(b) The extraction watermark image

Figure 5. Circular Area Mean Filtering Attack (Radius of 9)

(a) The attacked watermarked image

(b) The extraction watermark image

Figure 6. JPEG Compression (50:1)

From the different attacked watermark image extracted watermark in the image of each subband coefficient values as shown in Table1.

Table 1. The Extracted Watermark Image of each Subband Relationship Value

Attack types		each subband relationship value NC			
		LL	HL	LH	HH
Mean filter	4*4windows	0.6389	0.3876	0.3486	0.3727
	8*8 windows	0.2688	0.3358	0.3345	0.3556
Gauss filter	5*5 windows	0.8505	0.9865	0.7625	0.7868
	8*8 windows	0.8252	0.4860	0.3526	0.3796
Circular area mean	Radius of 7	0.2294	0.2889	0.3113	0.3832
filter	Radius of 9	0.2476	0.3865	0.2917	0.3455
JPEG	Quality 30%	0.4928	0.3908	0.3132	0.3335
Compression	Quality 50%	0.4143	0.5053	0.3721	0.3812
Rotation	Rotating 10 degrees	0.3249	0.3725	0.3722	0.4039
	Rotating 30 degrees	0.2995	0.3836	0.3869	0.3843

4. Conclusion

In this paper, the good characteristics of multiresolution and time-frequency local analysis of discrete wavelet transform combining with image intrinsic algebraic properties of SVD, proposed a new digital watermarking scheme [5]. The watermark is embedded into the host image by LL, HL, LH and HH subbands, and can be successfully extracted from each subband watermarking images. Because LL subband representation is determined by the wavelet transform decomposition series of the largest scales under different resolutions of the optimal approximation of the original image, most of the energy of the image are concentrated in this. In these places the embedded watermark is not easy to be lost, but LL changed easy to affect the quality of the image,So if the watermark is embedded into the host image subband LL, can distort the host image to bring visual results, Which means that the feature of digital watermark invisibility is reduced greatly [5]. However, we can be known from Table 1, it contains a variety of common geometric attacks for attack is still robust. If the watermark information is embedded into the other three subbands, even by the common attacks, they still has certain robustness and invisibility.

To sum up, the method of geometric attacks and other common attacks is robust. Compared with the watermarking algorithm directly using the SVD decomposition, more robust.

Acknowledgements

Project supported by the National Natural Science Foundation (40751128) and Hubei social sciences major project (2012WT007) and Scientific research project in hubei province department of education (B20110807) supported.

References

[1] Ye Yun, Jiang Tianfa. A Scheme of digital image watermarking based on DCT and Contourlet transform domains. *Engineering journal of WUHAN University*. 2012; 45(2): 264-267.
[2] Ge Xiuhui, Tian Hao. *Research on Application of Reversible Digital Watermark Algorithm.* Proceedings of the 2008 International Conferenceon Computer Science and Software Engineering. 2008; 3: 810-813.
[3] Song Qiang, hang Hongbin. *Color Image Self-Embedding and Watermarking Based on DWT*. International Conference on Measuring Technology and Mechatronics Automation. 2010: 796-799.
[4] Kin Tak U, Sheng Dun Hu, Dongxu Qi, Zesheng Tang. *A Robust Image Watermarking Algorithm based on Non-Uniform Rectangular Partition and DCT-SVD*. International Conference on Measuring Technology and Mechatronics Automation. 2010: 327-330.
[5] Feng Wen-ge, Liu Lei. SVD and DWT Zero-bit Watermarking Algorithm,2010 2nd International Asia Conference on Informatics in Control. *Automation and Robotics.* 2010: 361-364.
[6] Gaurav Bhatnagar, Balasubramanian Raman. A new robust reference watermarking scheme based on DWT-SVD. *Computer Standards & Interfaces*. 2008; (3): 15-17.
[7] Ming-Shi Wang, Wei-Che Chen. A hybrid DWT-SVD copyright protection scheme based on k-means clustering and visual cryptography. *Computer Standards & Interfaces*. 2006; (3): 20-23
[8] Zhang Xiao-ping Li Kan Comment on an SVD based watermarking scheme for protecting rightful ownership. *IEEE transactions on Multimedia.* 2005; 7(2): 593-594.
[9] Roman R. Comment on-an SVD-based watermarking scheme for protecting rightful ownership, *IEEETransactions on Multimedia*. 2007; 9(2): 421-423.
[10] Xiao Liang, Wei Zhihu,i Ye Jianbing. Commants on an SVD-based watermarking scheme for protecting rightful ownership.and theoretical analysis. *Journal of Electronic Imaging*. 2008; 17(4): 040501.