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New Robust Digital Image Watermarking using DWT, DCT and SVD

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Abstract : - In this paper, we have presented algorithm for robust digital image watermarking using DWT, DCT and SVD domain coefficients. Discrete wavelet transform is used to improve robustness of the algorithm. In this paper, only low frequency coefficients (LL band) of DWT are transformed into frequency domain using DCT. The watermark image is embedded into singular diagonal matrix of SVD decomposition of DCT frequency representation of LL band. As the algorithm does not alter any pixel information of cover image, it will not affect quality of cover image. This algorithm is blind watermarking. Security is improved by using unique similarity key technique. Results show that, this algorithm is robust against compression, noise and geometric attacks. Our motivation of image authentication is proved by calculating correlation coefficient between embedded data and extracted data.

Keywords:Digital image watermarking, discrete wavelet transform (DWT),discrete cosine transform (DCT),singular value decomposition (SVD) and message digest (MD algorithm).

(I) INTRODUCTION

In this era of information technology, data sharing and multimedia data protection is challenging problem. The vast use of internet and social media breaks laws of data copyright and digital ownership. Security of digital data is lost and piracy of information is increased. This all make loss of profit, skill and talent of artist or waste of the intellectual property of commercial companies.

For overcome such security and copyright challenges, the digital watermarking technique is the effective prevention method. In early days, for security of currency was issue. This problem was solved by adding transparent faint watermark in the currency paper. This is traditional method of watermarking but now days we have digital data to secure and authenticate. So, we will embedded unique information in the digital data. Watermark is the digital unique data which have to embed in image / audio or video signal to prove authentication of copyright of digital data. Watermark may any digital information like digital logo, legal information, certification of ownership or tag line of company. During embedding and extracting of watermark, the key is used to improve the security of algorithm. If same key is used for both embedding and extraction process then it is symmetrical key method otherwise asymmetrical key method. The key is generated from different encryption algorithm like CRC, AES, RSA and MD algorithms.

The digital image watermarking is of two types :

1) Spatial domain watermarking
2) Frequency domain watermarking.

The spatial domain watermarking is less robust to communication noise attack than frequency domain watermarking algorithms. LSB(least significant bit),OPAP (optimal pixel adjustment process), pixel replacement are different ways of spatial domain watermarking. The frequency domain watermarking uses DWT, DCT, FFT and SVD transforms. Frequency domain watermarking is robust, invisible and prevent watermark from

geometric, filtering and compression attacks. In this paper, we are using only frequency domain information for watermark embedding. In part (II), we will discuss the image transforms used. In next section, we discuss embedding and extraction scheme of proposed algorithm. The experimental result and conclusion are discussed in next sections.

(II) IMAGE TRANSFORM

1) Discrete wavelet transform (DWT):

For wavelet filtering of 2-D image, discrete wavelet transform is used. As DWT gives multiresolution analysis of the cover image at different scales and levels. The resolution of the signal is a measure of the amount of detail information in the signal. The resolution of signal is changed by the filtering operations and the scale is changed by the upsampling and downsampling techniques. This is done even using DWT2 in Matlab. In Matlab, there are many wavelet filter families as Haar, Daubechies, Bio-orthogonal, and Symlet wavelet transform.

The single level wavelet decomposition gives four subbands of an original image as low low frequency subband (LL), low high frequency subband(LH), high low frequency subband(HL) and high high frequency subband (HH). LL is an approximation of original image but scale down by factor of 2. The LH,HL,HH sub-bands are detail information of horizontal, vertical and diagonal details of downsampled original image. Image representation of DWT decomposition is representation as below

Fig. 1.single level wavelet decomposition

2) Discrete cosine transform (DCT) :

2D-DCT is the real value transform used in digital image watermarking. Here DCT is used to get frequency representation of the input image. The discrete cosine transform represents an image as sum of sinusoids of varying magnitudes and frequencies. DCT is orthogonal transform having best energy compression and widely used in image compressions.

Let $A_{(NXN)}$ be image whose DCT coefficients are calculated using formula given below

And equation of inverse 2-D DCT is given by

Where, $u = 0,1,\ldots N-1$ and
$v = 0,1,\ldots,N-1$.

$C_u, C_v = \sqrt{1/N}$ when $u, v = 0$;
$= \sqrt{2/N}$ otherwise.

3) Singular value decomposition (SVD):

This is a type matrix factorization or decomposition into the unique matrices. SVD is widely used in image processing for feature extraction in biometric work. The rank of image matrix of NxN size is equal to number of the non zero rows. The SVD factorizes image matrix $A_{(NXN)}$ as

$$A_{(MXN)} = U_{(MXM)} * S_{(MXN)} * V^T_{(NXM)} .$$

where, matrix $U_{(MXM)}$ & $V_{(MXN)}$ are orthogonal matrices and $S_{(NXN)}$ is a diagonal matrix with singular value ad diagonal as

$$S = \begin{bmatrix} \sigma_1 & 0 & \cdots & 0 & 0 & \cdots & 0 \\ 0 & \sigma_2 & \cdots & 0 & 0 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sigma_r & 0 & \cdots & 0 \\ 0 & 0 & \cdots & 0 & \sigma_{r+1} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & 0 & 0 & \cdots & \sigma_n \\ 0 & 0 & \cdots & 0 & 0 & \cdots & 0 \end{bmatrix} \quad ...(3)$$

the singular values having property as

(III) PROPOSED ALGORITHMS:

Let I(x,y) be an image of size(512X512). I(x,y) and W(x,y) are both gray scale images used as cover and watermark image respectively. WI(x.y) be the watermarked image after embedding W(x,y) into I(x,y) image. Here in this section, we will discuss schemes of watermark embedding and then extracting it.

1)Watermark embedding algorithm :

Let K be the key generated from red plane of cover image using MD5 algorithm. The MD5 is message digest algorithm used to generate unique 128-bits checksums.The steps involved are

(I) Apply 2D-DWT to cover image I(x,y) to decompose it into four subbands as LL1,LH2,HL2,HH2.

(ii) Apply 2D-DCT to low frequency subband LL1 to transform it into frequency domain.

(iii) Then factorize output of DCT of LL1 using Singular value decomposition as

$$I(x,y) = U(x,y) * S(x,y) * V^T(x,y).$$

(iv) Apply previous all steps to watermark image W(x,y).

(v) Now, modify the diagonal matrix of SVD of cover image as

$$WS(x,y) = S(x,y) + \alpha * s\_w(x,y). \quad ...(4)$$

where, S(x,y)=diagonal matrix of cover image s_w(x,y)= diagonal matrix of SVD of DCT of diagonal details of watermark image.

(vi) Multiply three matrices U(x,y),V^T(x,y) & WS(x,y) to get new DCT representation.

(vii) Apply inverse DCT to get new watermarked LL1and inverse DWT to get watermarked image.

The key K is then send to authenticate user only and watermarked image is uploaded on internet or transmitted to sender.

2) Watermark extraction algorithm:

At receiver, same key K is needed to proceed extraction algorithm. Here we are using symmetrical key technique, thatimproves security of algorithm. After key matching, some steps from (i) to (iv) are applied to watermarked image WI(x,y) as embedding algorithm. Then,

(v) Extract diagonal matrix of watermark as

$$WI(x,y) = WU(x,y) * WS(x,y) * WV^T(x,y).$$

$$s\_w(x,y) = \alpha * (WS(x,y) - S(x,y)) \quad (5).$$

(vi) Multiply three factors of watermark image matrix as

$$new\_W\_dct(x,y) = u\_w(x,y) * s\_w(x,y) * v\_w^T(xy)$$

where; u_w,s_w and v_w are svd of watermark image calculated during embedding watermark.

(vii) Apply inverse DCT to output of step (vi) and then apply IDWT to get watermark image.

Now new_W(x,y) be the extracted watermark form watermarked image WI(x,y).

(IV) EXPERIMENTAL RESULT

The MATLAB R2010 software environment used for implementation of our algorithm. The Lena (512X512) image and cameraman (256X256) in BMP file format are used as cover and watermark image respectively.

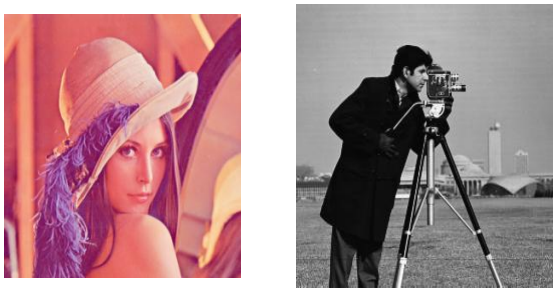

Fig.2 Coverand Watermark Image respectively.

The parameters to test the robustness of proposed algorithm are PSNR (peak signal to noise ratio) in dB, MSE (mean square error) and NC (normalized correlation).Let NC be normalized correlation between cover image and watermarked image. For ownership right proof, Normalized correlation between watermark embedded and watermark extracted is calculated which denoted as NC_wm. The significance of NC_wm is that, high the vale of it means watermarks are more correlated (similar). The mathematical formulations of parameter discussed are as

The result calculated without applying any attacks are

PSNR in dB = 32.1918
MSE = 39.5638
NC = 0.9916
NC_wm = 0.9999

The proposed algorithm is much robust against JPEG compression, filtering and noise attacks. The stirmark is benchmark used to apply attacks to watermark image. Results against attacks are tabulated in table 1. Even under attack NC_wm is high enough to prove the ownership of digital image data. And this algorithm is also robust in case of other data formats.

Attack applied	PSNR in dB	MSE	NC_wm
JPEG	24.8813	213.0284	0.9981
Median filtering	23.8790	252.9049	0.9990
Noise	9.8417	5.6301 e^{004}	0.9976
PSNR	26.0231	262.8602	0.9989
Self similarity	5.7088	1.7604 e^{004}	0.9999

Table. 1 Parameter calculated under result

(V) COCLUSION

In this paper, a robust and complex algorithm for digital image watermarking is proposed. This is blind watermarking algorithm in which low frequency coefficients are modified without any pixel information alteration in spatial domain. Hence, any pixel information may not loss. The aim of this paper that authentication of image is achieved and copyrights ownership is proved.

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