International Journal of Advance Engineering and Research Development (IJAERD)
Volume 1,Issue 5,May 2014, e-ISSN: 2348 - 4470 , print-ISSN:2348-6406

Invisible Digital Watermarking using Discrete Wavelet Transformation and Singular Value Decomposition

Nilay Mistry[1], Dhruv Dave[2]

[1]*Computer Department, KSV University L.D.R.P Institute of Technology and Research, Ghandhinagar, India,nil171190@gmail.com*
[2]*Assistant Professor, Computer Department, KSV University, L.D.R.P Institute of Technology and Research, Ghandhinagar, Indiadhruvdave.ce@gmail.com*

Abstract— The main goal of developing an invisible digital watermarking algorithm is to satisfy an imperceptibility requirement. Imperceptibility implies that embedded watermark is invisible to naked eyes. To achieve this objective, a hybrid image watermarking scheme based on discrete wavelet transformation (DWT) and singular value decomposition (SVD) is proposed in this paper. In our proposed method, the watermark is not directly embedded on the watermark coefficients. But here first we apply DWT and SVD to cover image and watermark image, modify the singular value of the cover image with singular value of watermark image using sub bands and then perform inverse DWT to get the Watermarked image. We have obtained the experimental results by calculating PSNR values of sample images. Experimental results illustrate that higher the PSNR values we gets less degradations in watermarked image using our proposed method.

Keywords— Authentication, copyright protection, digital watermarking, discrete wavelet transform (DWT), singular value decomposition (SVD).

I. INTRODUCTION

These days the increments utilization of the Internet has quickly expanded the accessibility of computerized information i.e. images, audio, videos & texts to the end clients. We all need to ensure our images from unapproved use, yet in the meantime; we would prefer not to do anything to diminish the visual appearance, since that is the entire purpose of posting the work in any case. As we have seen in the past few months, the issue of ensuring interactive media data gets more vital and a ton of copyright holders are worried about securing any illicit duplication of their information or work[1]. For that a few genuine work needs to be carried out to secure and keep up the interactive media information of inventors, merchants or straightforward clients. Among the numerous methodologies accessible to ensure media data, "Digital Watermarking" is presumably the best suitable so as to its strength. Owing to the popularity of the Internet and the rapid growth of multimedia technology, users have more and more chances to use multimedia data. Consequently, the protection of the intellectual property rights of digital media has become an urgent issue. Digital watermarking has attracted considerable attention and has numerous applications, including copyright protection, authentication, secret communication, and measurement [5], [6]

According to the domain in which the watermark is inserted, these techniques are classified into two categories, i.e., spatial-domain and transform-domain methods. Embedding the watermark into the spatial-domain component of the original image is a straightforward method. It has the advantages of low complexity and easy implementation. However, the spatial-domain methods are generally fragile to image-processing operations or other attacks. On the other hand, the representative transform-domain techniques embed the watermark by modulating the magnitude of coefficients in a transform domain, such as discrete cosine transform, discrete wavelet transform (DWT), and singular value decomposition (SVD) [2], [3]. Although transform domain methods can yield more information embedding and more robustness against many common attacks, the computational cost is higher than spatial-domain watermarking methods.

Due to its excellent spatial-frequency localization properties, the DWT is very suitable to identify areas in the cover image where a watermark can be imperceptibly embedded. One of attractive mathematical properties of SVD is that slight variations of singular values do not affect the visual perception of the cover image, which motivates the watermark embedding procedure to achieve better transparency and robustness.

Since performing SVD on an image is computationally expensive, this study aims to develop a hybrid DWT-SVD-based watermarking scheme that requires less computation effort to yield better performance. After decomposing the cover image into four sub bands by one-level DWT, we apply SVD only to the intermediate frequency sub bands which are LH & HL and embed the watermark into the singular values of the aforementioned sub bands to meet the imperceptibility requirements.

II. BACKGROUND REVIEW AND THE PROPOSED APPROACH

A. Discrete Wavelet Transformation (DWT)

The DWT has received considerable attention in various signal processing applications, including image watermarking. The main idea behind DWT results from multiresolution analysis [4], which involves decomposition of an image in frequency channels of constant bandwidth on a logarithmic scale. It has advantages such as similarity of data structure with respect to the resolution and available decomposition at any level. The DWT can be implemented as a multistage transformation. An image is decomposed into four sub bands denoted LL, LH, HL, and HH at level 1 in the DWT domain, where LH, HL, and HH represent the finest scale wavelet coefficients and LL stands for the coarse-level coefficients. The LL sub band can further be decomposed to obtain another level of decomposition. The decomposition process continues on the LL sub band until the desired number of levels determined by the application is reached. Since human eyes are much more sensitive to the low-frequency part (the LL sub band), the watermark can be embedded in the other three sub bands to maintain better image quality.

B. Singular Value Decomposition (SVD)

From the perspective of image processing, an image can be viewed as a matrix with non-negative scalar entries. The SVD of an image A with size $m \times m$ is given by $A = USV^T$, where U and V are orthogonal matrices, and $S = \text{diag}(\lambda_i)$ is a diagonal matrix of singular values λ_i, $i = 1, \dots, m$, which are arranged in decreasing order. The columns of U are the left singular vectors, whereas the columns of V are the right singular vectors of image A. The basic idea behind the SVD-based watermarking techniques is to find the SVD of the cover image or each block of the cover image, and then modify the singular values to embed the watermark. There are two main properties to employ the SVD method in the digital-watermarking scheme: 1) When a small perturbation is added to an image, large variation of its singular values does not occur. 2) Singular values represent intrinsic algebraic image properties [2].

C. Proposed DWT-SVD based Watermarking Scheme

1) Watermark Embedding:

1. Use one-level DWT to decompose image into four sub-bands(LL,LH,HL,HH)
2. Apply SVD to LH and HL sub-band

   $A^k = U^k S^k V^{kT}$; k=1,2 (1)

   Where k represents sub bands
3. Apply SVD to watermark image.
4. Modified the singular value of sub bands of cover image using watermark. i.e.,

   $S^k + \alpha W^k = U_W{}^k \; S_W{}^k \, V_W{}^{kT}$ (2)

   Where α denotes the scale factor. The scale factor is used to control the strengths of the watermark to be inserted.

5. Obtain modified DWT coefficients.

   $A^{*k} = U^k S_W{}^k \; V^{kT}$; k=1,2 (3)

6. Obtain the watermarked image $\boldsymbol{A_W}$ by performing the inverse DWT using two sets of modified DWT coefficients and two sets of non modified DWT coefficients.

2) Watermark Extracting:

1. Use one-level DWT to decompose the watermarked (possibly distorted) image $A^*{}_W$ into four sub bands: LL, LH, HL, and HH.
2. Apply SVD to LH and HL sub bands, i.e.,

   $A_W{}^{*k} = U^{*k} S_W{}^{*k} V^{*kT}$; k=1, 2 (4)

3. Extract watermark image from each sub-band.

   $W^{*k} = (D^{*k} - S^k)/\alpha$ (5)

   Where α represents scale factor

4. Compute $D^{*k} = U_W{}^k \; S_W{}^{*k} \; V_W{}^{kT}$ (6)
5. Apply inverse DWT to obtain watermark image back.

III. EXPERIMENTAL RESULTS

Several experiments are carried out to measure the performance of this approach. The gray scale image “Cameraman.tif” of size 256 x 256 is taken as a cover image and “Coins.png” of size 256 x 256 is taken as a watermark image. To measure the imperceptibility, here we use wavelet filters named Haar, Daubechies and Symlets and alternatively done experiments using different filters on sample images and calculate PSNR values to know that which wavelet filter is better to provide better imperceptibility.

As a measure of the quality of a watermarked image, the peak signal to noise ratio (PSNR) is used. As higher the value of PSNR as we get less distortion in watermarked image. In the following figure we saw a cover image, watermark image and watermarked image using haar filter with the scale factor of 0.05.

(a) (b) (c)

Fig. 1 (a) Cover image, (b) Watermark, (c) Watermarked image

Following TABLE I shows the PSNR value comparison of different filters from wavelet families i.e., here we take Haar, Daubechies and Symlets. Here we take three values of scale factor which are 0.05, 0.10 and 0.15.

TABLE I
PSNR VALUE COMPARISION OF WAVELET FILTERS

Wavelet Filters		**PSNR values**		
		α = 0.05	**α = 0.10**	**α = 0.15**
Haar	haar(db1)	22.9470	22.8161	22.6844
Daubechies	db2	24.1245	24.0097	23.8943
	db3	24.3765	24.2612	24.1582
	db4	24.3838	24.2784	24.1713
	db5	24.4155	24.3134	24.2097
	db10	25.0152	24.9157	24.8153
Symlets	sym2	24.1245	24.0097	23.8943
	sym8	24.8142	24.7189	24.6230

By the experiments carried out shown in above table, it is clear that Daubechies family filters have good PSNR values which directly indicates that watermarking by this filter gets less distortions in watermarked image. And here db10 filter gives better result than others.

It is also clear that as we increase the scale factor, we get less PSNR values. So we can take α= 0.05 as a standard scale factor.

Following images shows the watermarked images for given filters for α= 0.05.

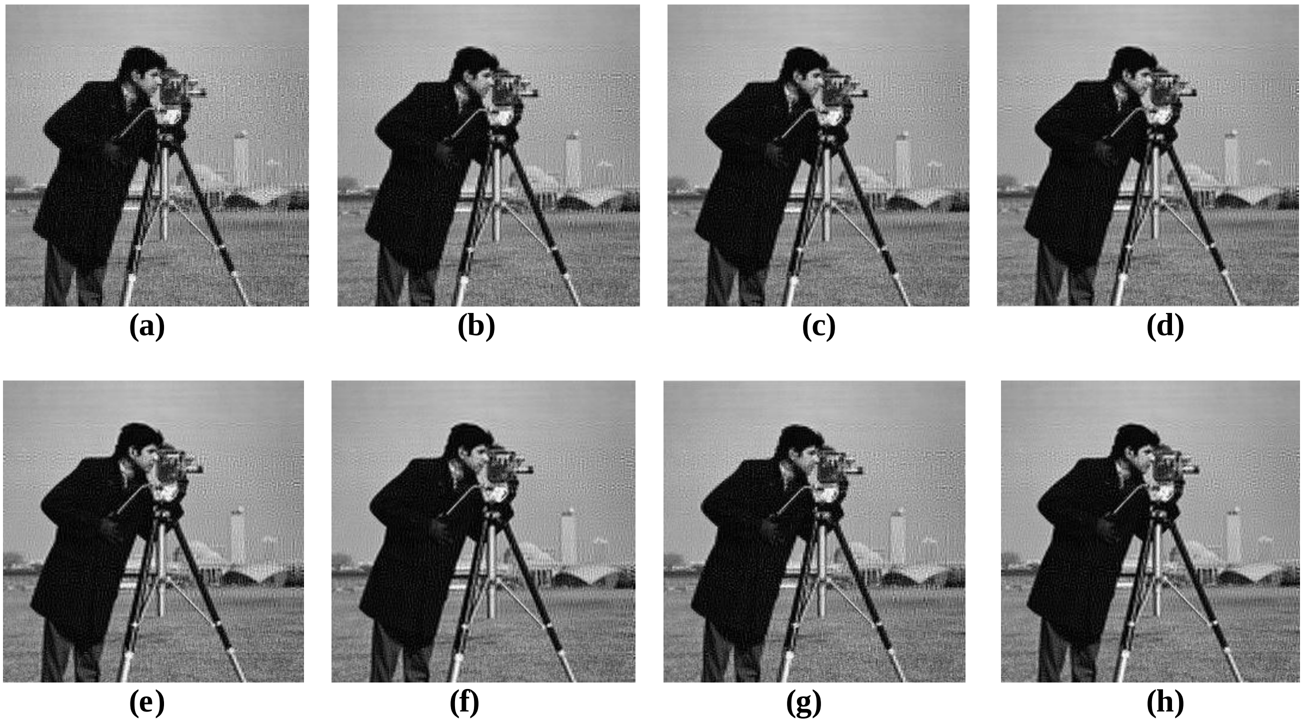

Fig. 2 Watermarked images of the filters (a)haar, (b)db2, (c)db3, (d)db4, (e)db5, (f)db10, (g)sym2, (h)sym8

By the above figure it is clear that as we get more PSNR value we get less distortions in watermarked image.
Figure (f) which is of db10 watermarked image is less attenuated by performing our proposed DWT-SVD based scheme.

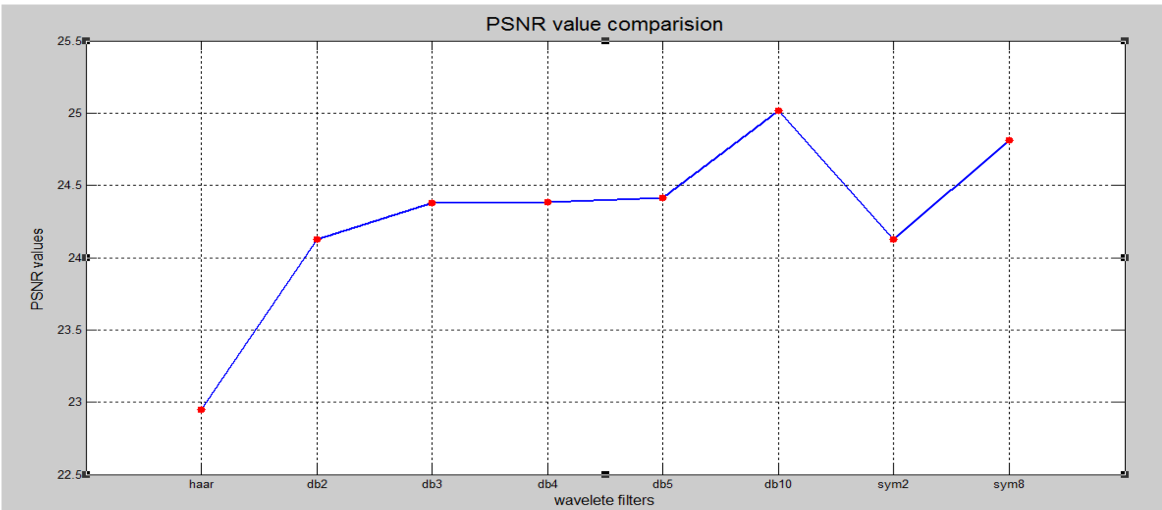

Fig. 3 PSNR value comparisons of wavelet filters

We implemented our proposed invisible watermarking method using MATLAB on a personnel computer with Intel Core 2 Duo Processor rated 2.0 GHz, main memory 3 GB and operating system of Microsoft Windows 7.

Experimental results listed in TABLE I. It is clear that our proposed dwt-svd based method gives better result for several wavelet filters.

IV. CONCLUSION

In this paper, a hybrid DWT-SVD based invisible watermarking technique has been presented, where the singular values of the cover image's sub bands is modified by the singular value of the watermark image's sub bands with scale factor and applying inverse dwt to get the watermarked image. The technique fully exploits the respective feature of these two transform domain methods: spatial-frequency localization of DWT and SVD efficiently represents intrinsic algebraic properties of an image. Experimental results of the proposed method shows the significant improvements in imperceptibility which is measured by PSNR values. The higher the PSNR value, there is less distortion in watermarked image. We have also done experiments for several wavelet filter from wavelet family i.e., Haar, Daubechies, symlets. And found that in Daubechies family db10 method is better than other filters.

Future work can be done by applying 2 – level dwt on images than apply dwt-svd based method on sub bands of cover image and calculate PSNR values and our proposed method DWT-SVD based only work on gray scale images so it can be extend to color images also.

REFERENCES

[1] Darshana Mistry, "Comparison of Digital Water Marking methods," (IJCSE) InternationalJournalon Computer Science and Engineering, Vol. 02, No. 09, 2010, 2905-2909

[2] R. Liu and T. Tan, "An SVD-based watermarking scheme for protecting rightful ownership," IEEE Trans. Multimedia, vol. 4, no.1, pp. 121–128, Mar. 2002.

[3] A. Nikolaidis and I. Pitas, "Asymptotically optimal detection for additive watermarking in the DCT and DWT domains," IEEE Trans. Image Process., vol. 12, no. 5, pp. 563 571, May 2003.

[4] S. Mallat, "The theory for multiresolution signal decomposition: The wavelet representation," IEEE Trans. Pattern Anal. Mach. Intell., vol. 11, no. 7, pp. 654–693, Jul. 1989.

[5] J.Sang and M.S.Alam, "Fragility and robustness of binary-phase-onlyfilter- based fragile/semifragile digital image watermarking," *IEEE Trans.Instrum. Meas.*, vol. 57, no. 3, pp. 595–606, Mar. 2008.

[6] H.-T.Wu and Y.-M. Cheung,"Reversible watermarking by modulation and security enhancement," *IEEE Trans. Instrum. Meas.*, vol. 59, no. 1, pp. 221–228, Jan. 2010.

[7] Chih-Chin Lai& Cheng-Chih Tsai, "Digital Image Watermarking Using Discrete Wavelet Transform and Singular Value Decomposition", IEEE, 11 Nov, 2010