# Performance Analysis of Digital Image Watermarking using Discrete Wavelet Transform, Discrete Cosine Transform and Singular Value Decomposition based on PSNR and NC

**Anjul Singh,Akash Tayal**
**Department of Electronics & Communication, IGIT,**
**Guru Gobind Singh Indraprastha University, Delhi – 110403, India.**
**aroma.singh@gmail.com,akashtayal@yahoo.com**

***ABSTRACT*-Several watermarking schemes have been proposed with the purpose to satisfy both imperceptibility and robustness requirements. In this paper, various watermarking scheme as Singular value decomposition (SVD), Discrete Wavelet Transform (DWT), an optimal Discrete Wavelet Transform-Singular Value Decomposition (DWT-SVD) based image watermarking scheme, and a hybrid watermarking scheme based on Discrete Wavelet Transform – Discrete Cosine Transform –Singular Value Decomposition (DWT-DCT-SVD) are discussed. In DWT-SVD based watermarking algorithm watermark is embedded on the elements of singular values of the cover image's DWT sub bands rather than on directly embedded on the wavelet coefficients.In DWT-DCT-SVD based watermarking algorithm the watermark is not embedded directly on the wavelet coefficients but rather than on the elements of singular values of the cover image's DCT of the DWT coefficients of the subband ofDWT. Experimental results show improvement both in imperceptibility and robustness requirements under certain attacks and also provide the comparative results in between these algorithms in terms of peak signal to noise ratio (PSNR) and normalised correlation(NC).**

***Index Terms*-Digital watermarking, discrete cosine transform (DCT), discrete wavelet transform (DWT), singular value decomposition (SVD).**

## *I.INTRODUCTION*

In the modern electronically-driven world, with the growth in internet and digital technology digital watermarking is the modern approach against piracy and maliciousmanipulation to authenticate visual data by imperceptibly embed a watermark signal into the data for copyright protection and exchange data.

By modifying the pixel values or the transform domain coefficients a watermark (*W*) can be embedded within a host image (*I)*.The larger the scaling factor (SF), the stronger the robustness and the more the distortion of the quality of the host image (transparency). On the other hand, the smaller the SF, the weaker the robustness and better is the image quality. Different subbands may exhibit different tolerance to modification so a single SF may not be applicable for modifying all sub bands. αis used to control the watermark strength. So before embedding process the watermark can be scaled by a scaling factor (α).Therefore, different scaling factors should be employed for watermarking the different subbands.

ISBN 978-1-4675-2248-9 © 2012 Published by Coimbatore Institute of Information Technology

Since performing SVD on an image is computationally expensive and it also has disadvantages as inability to withstand attacks.But SVD offer a robust method with minimum or no distortion of watermarking, this study aims to develop a hybrid DWT-SVD-based watermarking scheme that requires less computation effort to yield better performance. DCT based watermarking provide compression.DCT modulus contain the low frequency information so that watermarking image renewed well without losing information.DWT based compression offers scalability so that image can be decomposed into subbands and one can choose the subband which has minimum energy,this leads aims to develop a hybrid SVD-DCT-DWT based watermarking scheme to provide robustness and recoverable visual watermark by passing them through different attacks with small or very reasonable amount of distortion.

## *II. RELATED WORKS*

### *SVD-Based Watermarking*

Inimage processing, an image can be defined as a matrix with nonnegative scalar entries. Any image $I$ with size $m \times n$ is decomposed and expressed as $I = USV\ T$, where $U$ and $V$ are orthogonal or unitary matrices, and $S = \text{diag}(\lambda i)$ is a diagonal matrix of singular values $\lambda i$, $i = 1, \ldots, m$, which are arranged in decreasing order. The first r columns of $U$ are the left singular vectors, whereas the r columns of $V$ are the right singular vectors of image I[6,7]. 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) Singular values in a digital image are less affected because bigger singular values not only resist against attacks but also preserve most energy of an image . 2) Singular values represent intrinsic algebraic image properties means each singular value specifiesthe luminance of an image layer [8].

### *DWT Based Watermarking*

The DWT has received considerable attention in image watermarking, due to its excellent spatio-frequency localization properties to identify the area for embedding a watermark in the host image. The main idea behind DWT results from multiresolution analysis [13], which involves decomposition of an image in frequency channels of constant bandwidth on a logarithmic scale and providing four non-overlapping multiresolution subbands denoted LL, LH, HL, and HH at level 1 in the DWT domain. Generally most of the image energy is concentrated at lower frequency subbands LLx [11] and modification to the coefficients of the lower frequency LLx channel would cause severe degradation in the image quality. On the other hand HHx high frequency [12] subbands are not suitable for embedding a watermark to provide resiliency to the attack by filtering operations and lossy compression.

In an image, LH, HL, and HH represent the finest scale wavelet coefficients and LL stands for the coarse-level coefficients. To obtain another level of decomposition the LL sub band can further be decomposed 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 subband), the watermark can be embedded in mid frequency channels to maintain better image quality.

ISBN 978-1-4675-2248-9 © 2012 Published by Coimbatore Institute of Information Technology

### *DWT- SVD Based Watermarking*

Wavelets are the special functions which are used as basal functions for representing the signal. This transform is a time domain localised analysis method with fixed window's size and convertible form. By filtering data that will be transformed through low pass and high pass filters DWT process is realized. The unit (number) of the above process is decomposition level [2].

This watermarking algorithm initially decomposes the cover image I into four subbands by one-level DWT, afterwards determines the singular values of each subband and modifies these singular values with the watermark by scaling with the scaling factors[5]. SVD decomposes an $M$x$N$ real matrix $I$ into a product of 3 matrices $I=US\ V^T$where $U$ and $V^T$are $M$x$N$ and $N$x$N$ orthogonal matrices, respectively. $S$ is an $N$x$N$ diagonal matrix. We apply SVD only to the intermediate frequency sub bands and embed the watermark into the singular values of the aforementioned subbands to meet the imperceptibility and robustness requirements. The main reason of combining DWT and SVD is that firstly this scheme is robust to various attacks, secondly this approach needs less SVD computation than other methods, thirdly this approach directly embeds the watermark into the singular values of the cover image to better preserve the visual perceptions of images.

### *DWT-DCT- SVD Based Watermarking*

DCT is most common linear transform which turns over the image edge to make the image transformed into the form of even function toobtain the wide spreading application in the compression coding. Wavelet transform is capable of providing a time-frequency representation of the signal.SVD provide minimum distortion and low computationalcost. So a hybrid DWT-DCT-SVD based watermarking scheme is developed in which DWT is applied to a cover image I[1,4,9,10].Then DCT is applied to the DWT coefficients,after that SVD is applied to each quadrant. Next step is to implement two level of DWT to the watermark and apply SVD to DCT transformed visual watermark. Then Modify the singular values in each quadrant $B_k$, $K$=1,2, 3, 4 with the singular values of the DCT transformed visual watermark and obtain modified DCT coefficient .At last apply inverse DWT to produce original cover image .Follow inverse procedure of embedding the watermark for extracting it from the cover image.

## *III. EXPERIMENTAL RESULTS*

Several experiments are presented to demonstrate the performance of the proposed approach. The gray-level images "Lena" of size 256 * 256 and "MCK" of size 64*64 are used as the cover image and the watermark, respectively for all the given algorithm. These images are shown in Fig. 1(a) and (b). It can be observed that the discussed approach preserves the high perceptual quality of the watermarked image.


Fig.1(a) Cover Image Fig1.(b)Watermark

As a measure of the quality of a watermarked image, the peak signal-to noise ratio (PSNR) was used. To evaluate the robustness of the proposed approach, the watermarked image was tested against attacks: 1) geometrical attack: rotation (RO); 2) noising attack: Gaussian noise (GN); 3) speckle noise; and 4) image-processing attack: histogram equalization (HE), contrast adjustment (CA), and Motion Blur. In the experiments, the values of the scale factors are carried out with constant range from 0.01 to 0.05with the interval of 0.02 and the results are illustrated in Tables I and II.

<u>Table I</u>

COMPARISION OF IMPERSEPTIBILITY (PSNR) FOR SVD, DWT, SVD-DWT and DWT-DCT-SVD BASED WATERMARKING

| **Watermarking Scheme** | **PSNR(db)** |
|---|---|
| **SVD Based Watermarking** | 48.31 |
| **DWT Based Watermarking** | 33.84 |
| **SVD-DWT Based Watermarking** | 48.48 |
| **DWT-DCT-SVD Based Watermarking** | 42.00 |

Tables II

NORMALISED CORRELATION COEFFICIENT VALUES OF EXTACTED WATERMARKS FROM DIFFERENT ATTACKS IN SVD-DWT and DWT-DCT-SVD BASED WATERMARKING

| Attack | LL Sub-band SVD-DWT Watermarking | HL Sub-band SVD-DWT Watermarking | DWT-DCT-SVD Watermarking |
|---|---|---|---|
| No Attack | 1 | 1 | 1 |
| Adjust image intensity (f,[],[0.4,1]) | 0.9454 | 0.9454 | 0.9841 |
| Adjust image intensity (f,[],[0,0.95]) | 0.9459 | 0.9469 | 0.9840 |
| Adjust image intensity (f,[0.2,0.6],[]) | 0.9214 | 0.9260 | 0.9840 |
| Adjust image intensity (f,[],[0.2,0.8]) | 0.9469 | 0.9469 | 0.9841 |
| Speckle Noise | 0.9256 | 0.9276 | 0.9840 |
| Gaussian Noise | 0.9341 | 0.9224 | 0.9839 |
| Rotate Image 45 Degree | 0.9109 | 0.9233 | 0.9794 |
| Histogram Equalisation | 0.9370 | 0.9266 | 0.9840 |
| Sharpen Image | 0.9323 | 0.8779 | 0.9713 |
| Motion Blur(20,45) | 0.7507 | 0.2929 | 0.9839 |

## *IV.CONCLUSION*

In this paper, a comparison has been made using the PSNR for SVD, DWT, SVD-DWT AND DWT-DCT-SVD based image-watermarking technique. We also checked results for normalised correlation coefficients values of extracted watermark under different attacks in one level decomposition, three level decomposition SVD-DWT based watermarking and DWT-DCT-SVD based watermarking.Our comparative study shows that DWT-DCT-SVD based watermarking scheme have advantagesin some cases as speckle noise ,Gaussian noise ,adjusting image intensity, histogram equalisation and against rotation. Experimental results of the proposed technique have shown both the significant improvement in imperceptibility and the robustness under attacks.

ISBN 978-1-4675-2248-9 © 2012 Published by Coimbatore Institute of Information Technology

## *REFERENCES*

[1] S S Bedi, Ashwani Kumar, and Piyush Kapoor," Robust Secure SVD Based DCT – DWT Oriented Watermarking Technique for Image Authentication", in International Conference on IT, March 2009, Thailand.

[2]L. Zhang, A. Li, "Robust watermarking scheme based on singular value of decomposition in DWT domain," in Proc. Asia-Pacific Conf. Information Processing (APCIP '09), vol. 2, Shenzhen, July 2009, pp. 19-22.

[3] 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.

[4] K. A. Navas, M. C. Ajay, M. Lekshmi,T. S. Archana, M. Sasikumar, "DWT-DCT-SVD based watermarking," in Proc. 3rd Int. Conf.Communication Systems Software and Middleware and Workshops (COMSWARE '08), Bangalore, January 2008, pp. 271-274.

[5] E.Ganic and A.M. Eskiciogulu et.al., Robust embedding of Visual Watermarks using DWTSVD Journal of Electronic Imaging, October-December, 2005.

[6] W.C.Chu, DCT based image watermarking using sub sampling. IEEE Trans Multimedia 5, 34-38, 2003.

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

[8] Y. Yongdong Wu. On the Security of an SVD based Ownership Watermarking IEEE transactions on Multimedia, Vol 7. No.4, August, 2005. [9] M.Barni, M., Bartolini, F., V., Piva, A., Improved wavelet based watermarking through pixel-wise masking. IEEE Trans Image Processing 10, 783- 791, 2001.

[10] Chung, K.L., Shen, C.H., Chang, L.C., A Novel SVD and VQ-based image hiding scheme. Pattern Recognition Letters, 22, 1051-58, 2001.

[11] Chiou-Ting Hsu and Ja-Ling Wu. "Hidden digital watermarks in images," *IEEE Trans. Image Proc.*, vol. 8. no. I , pp. 58-68, January 1999.

[12] lngemar I. Cox, Joe Kilian, E Thomson highton. and Talal Shamoon, "Secure spread SpCClNm watermarking for multimedia,"*IEEE Trans. Image Proc.*, vol. 6, no. 12. pp. 1673-1687, December 1997.

[13] 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.

ISBN 978-1-4675-2248-9 © 2012 Published by Coimbatore Institute of Information Technology