# Image Watermarking Algorithm using Dct, Dwt and Svd

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## ABSTRACT
The growing problem of the unauthorized reproduction of digital multimedia data such as movies, television broadcasts, and similar digital products has triggered worldwide efforts to identify and protect copyright ownership of multimedia contents. In the last decade digital watermarking techniques have been devised to answer the ever-growing need to protect the intellectual property. discrete wavelet transform (DWT) and discrete cosine transform (DCT) are two most popular tools used in watermarking algorithm. With the increasing use of Singular Value Decomposition (SVD), the digital watermarking technology in transform domain has been greatly developed. Aim of this paper is to provide robust technique based on DWT, DCT and SVD, we propose a new watermarking algorithm for digital image. Experimental results show that this algorithm combines the advantages of these three transforms. It can satisfy the imperceptibility and robustness very well. This scheme is robust against all sorts of attacks. It has very high data hiding capacity.

## General Terms
Digital Watermarking, Robustness, Imperceptibility, Watermark embedding, Watermark Extraction.

Watermarking is the process of embedding a piece of digital information into any multimedia data such as an image, audio or video file for the purpose of authentication.

## Keywords
Watermark, DWT, DCT, SVD

## 1. INTRODUCTION
The increasing importance of digital media, Hence it has become a common practice to create copy, transmits and distributes digital data. However it brings also new challenges as it is now straight forward to duplicate or even manipulate multimedia content. There is a strong need for protection of intellectual property of owners, creators and distributors. Digital image watermarking has been proposed as valid solution for this problem and it is one such technology that has been developed to protect digital images from illegal manipulations and probably the one that has received most interest.The principle of the watermark is to embed a piece of some additional information it the digital data and hide it in the digital content in such a way that it is inseparable from the data. It means that it remains present within the data after any decryption process. The objective is to produce an image that looks exactly the same to a human eye but still allows its constructive recognition in comparison with the owner's key if necessary. Watermarks can be embedded in the pixel/spatial domain or a transform domain [1]. There are three essential factors those are commonly used to determine quality of watermarking scheme.

### 1.1 Imperceptibility
It means quality of host image should not be destroyed by presence of watermark. [3, 4]

### 1.2 Robustness
Watermark should be difficult to remove or destroy. Robust is a measure of immunity of watermark against attempts to image modification and manipulation like compression, filtering, rotation, scaling, collision attacks, resizing, cropping etc. [5, 6]

### 1.3 Capacity
It includes techniques that make it possible to embed majority of information.

Spatial domain watermarking technique is easier and its computing speed is high, than transform domain watermarking. But the disadvantage is that it is not robust against common image processing operations. Transform domain techniques are introduced to increase the robustness of the digital media. The most frequent used methods are Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT) and In recent years, Singular Value Decomposition (SVD) has been started to use in watermarking as a different transform [7].

## 2. PRELIMINARIES

### 2.1 Discrete Cosine Transform
DCT is one of the most popular linear transforms on digital signal processing. It has been widely used because of its good capacity of energy compression and decorrelation.

$$C(u,v) = \alpha(u)\alpha(v)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)\cos[(2x+1)u\pi/2N]*\cos[(2y+1)v\pi/2N]$$

$$f(x,y) = \sum_{u=0}^{N-1}\sum_{v=0}^{N-1} \alpha(u)\alpha(v)C(u,v)\cos[(2x+1)u\pi/2N]*\cos[(2y+1)v\pi/2N]$$

### 2.2 Discrete Wavelet Transform
DWT is a transformation technique is used to represent an image in a new time and frequency scale by decomposing the input image into low frequency, middle and high frequency bands. The value of low frequency band is the averaging value of the filter whereas the high frequency coefficients are wavelet coefficients or detail values. The DWT can be used to decompose image as a multistage transform. In the first stage, an image is decomposed into four subbands LL1, HL1, LH1, and HH1, where HL1, LH1, and HH1 represent the finest scale wavelet coefficients, while LL1 stands for the coarse level coefficients, i.e., the approximation image. Fig.1 shows the one level wavelet decomposition of an

image.

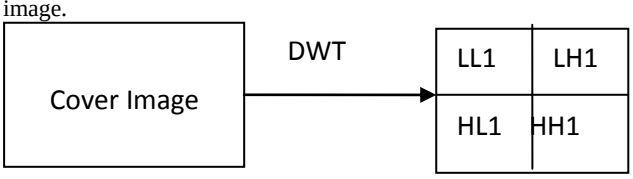


**Fig. 1 one level of Wavelet Decomposition**

## 2.3 Singular Value Decomposition

SVD is a mathematical tool used to analyze matrices. In SVD, a given matrix A is decomposed into three matrices such that, $A=U*S*V^T$ where U and V are orthogonal matrices and $U^T*U=I$, $V^T*V=I$, I is an identity matrix and S is the diagonal matrix (s11, s22, s33 ……sNN) such that s11>=s22>=s33……..s(N-1) (N-1)>=sNN. The diagonal entries of S are called the singular values of A, the columns of U are called the left singular vectors of A, and the columns of V are called the right singular vectors of A. This decomposition is known as the singular value decomposition (SVD) of matrix A. Usually, watermark is embedded in the singular matrix, and if the watermark is embedded in the orthogonal matrices of SVD then the perceptibility of host image is improved it is not robust to many attacks because the matrix elements of orthogonal matrices are very small. The three main properties of SVD from the view point of image processing applications are [8]:

1. The singular values of an image have very good stability, that is, when a small perturbation is added to an image, its singular values do not change significantly.

2. Each Singular value specifies the luminance of an image layer while the corresponding pair of singular vectors specifies the geometry of the image.

3. Singular values represent intrinsic algebraic properties.

## 3. PROPOSED ALGORITHM

Proposed algorithm combines the properties of DWT, DCT and SVD techniques to increase the robustness and capacity of the algorithm by selecting significant coefficients. The procedure for embedding and extracting the watermark is given below.

## 3.1 Watermark embedding process

The embedding process is divided into following steps and is briefly described as given below:

1. Let OI be the Original image of size 256 x 256. Apply DWT to decompose it into four 128 x 128 sub-bands LL , HL , LH and HH .
2. Select HH band and apply DCT to it and get DCT coefficient matrix B.
3. Apply SVD to B, $B=U*S*V^T$, and obtain U, S and V.
4. Let OW of size 256 x 256 to represent watermark. Apply DWT to decompose it into four 128 x 128 sub-bands WLL , WHL , WLH and WHH .
5. Select WHH band and apply DCT to it and get DCT coefficient matrix D.
6. Apply SVD to D, $D=U1*S1*V1^T$, and obtain U1, S1 and V1.
7. Modify S with watermark such that $S2=S + \alpha * S1$.
8. Obtain B* using $B^*= U*S2*V^T$.
9. Apply inverse DCT to B* to produce HH*.
10. Apply inverse DWT to LL, HL, LH and HH* to get watermarked image WI.

## 3.2 Watermark Extraction Process

The extraction process is divided into following steps and is briefly described as given below:

1. Apply DWT to WI to get LL, HL, LH and HH*.
2. Apply DCT to sub band HH* and get matrix A.
3. Apply SVD to A, $A= WU*WS*WV^T$ and obtain WU,WS,WV
4. Obtain $Sr=( S-WS ) /\alpha$.
5. Obtain $Wr= U1*Sr*V1^T$
6. Apply inverse DCT to Wr and get W.
7. Apply inverse DWT to LL, HL, LH and W and get extracted watermark EW.

## 4. EXPERIMENT RESULTS

The algorithm is tested on MATLAB 7.8.0, We apply our algorithm to various standard test images. Here we give the results of 256 x 256 grayscale image “Lena” and 256 x 256 grayscale watermark “Cameraman”. The robustness is tested under 9 types of attacks: Gaussian noise, low-pass filter, pepper & salt noise, contrast enhance, JPEG compression, cropping, and rotation, Histogram equalization, Gamma Correction, median filter. The images with attacks are shown in Figure 2. The Extracted Watermark with and without attacks are shown in Figure 3.

Normalized Correlation Coefficient is calculated to evaluate the robustness of algorithm NCC is defined as follows.

$$NC = \left(\sum_{i=0}^{M}\sum_{j=0}^{N} OW*EW\right)/\left(\sum_{i=0}^{M}\sum_{j=0}^{N} OW*OW\right)$$

Table 1 shows Normalized Correlation Coefficient calculated after different attacks.

**Fig. 2(a-k) images with various attacks**


(a) Original


(b) Watermarked


(c) Gaussian noise


(d) Low pass filter


(e) JPEG


(f) Contrast enhance


(g) Rotation and Crop


(h) Salt & paper



(i) Histogram equalization (j) Gamma Correction


(k) median filter

**Fig. 3(a-k) extracted watermark after various attacks**

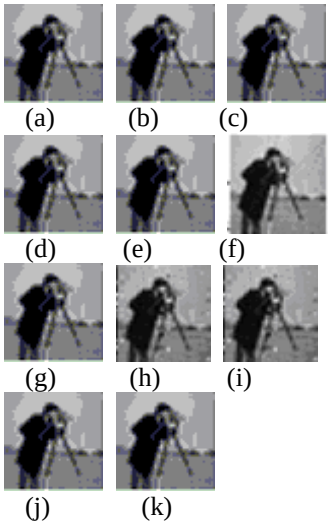
(a) (b) (c)
(d) (e) (f)
(g) (h) (i)
(j) (k)

**Table 1. Similarity measure of Extracted and Original Watermark after various attacks.**

| Various Attack | Normalized Correlation Coefficient |
|---|---|
| Without Attack | 0.9992 |
| Gaussian noise | 0.9992 |
| Low pass filter | 0.9996 |
| JPEG compression | 0.9996 |
| Contrast adjustment | 0.9995 |
| Rotation and crop | 0.9994 |
| Salt & pepper noise | 0.9995 |
| Histogram equalization | 0.9991 |
| Gamma Correction | 0.9993 |
| Median filter | 0.9995 |

## 5. CONCLUSIONS

In this paper, we proposed a watermarking algorithm for digital image based on DWT, DCT and SVD. The experiment shows it has a good performance on imperceptibility and robustness. It is more robust to some common image processing including Gaussian noise, low-pass filter, pepper & salt noise, contrast enhance, JPEG compression, cutting, and rotation than a SVD or a DCT+SVD algorithm.

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## 7. REFERENCES

[1] F.Hartung and M. Kutter, "Multimedia Watermarking Techniques," in proc. of the IEEE, vol. 87, no. 7, pp. 1079-1107, July 1999.

[2] Ali Al-Haj "Combined DWT-DCT Digital Image Watermarking," Journal of computer science 3 (9),740-746, ISSN, 2007.

[3] W. Bender, D. Gruhl, N. Morimoto and A. Lu, "Techniques for data hiding," IBM Systems Journal, vol.35, no. 3&4, pp. 313-336, 1996.

[4] I. J. Cox, J. Killian, F. T. Leighton and T. Shamoon,"Secure spread spectrum watermarking for multimedia,"IEEE Transactions on Image Processing, vol. 6, no. 12,pp. 1673-1687, December 1997.

[5] J. J. K. 0 Ruanaidh, W. J. Dowling and F. M. Boland, "Watermarking digital images for copyright protection,"IEE Proceedings - Vision, Image and Signal Processing, vol. 143, no. 4, pp. 250-256, August 1996.

[6] M. D. Swanson, M. Kobayashi and A. H. Tewfik, "Multimedia data-embedding and watermarking techniques," Proceedings of the IEEE, vol. 86, no. 6, pp.1064-1087, June 1998.

[7] Feng Liu, Yangguang Liu. A Watermarking Algorithm for Digital Image Based on DCT and SVD. Congress on Image and Signal Processing, 2008. CISP '08.

[8] Jung-Chun Liu, Chu-Hsing Lin, and Li-Ching Kuo" A Robust full band image watermarking scheme" Proceedings on IEEE .2006.

[9] Dr. Ekta Walia , Payal Jain , Navdeep "An Analysis of LSB & DCT based Steganography" Global journal of computer science and technology,Vol. 10,pp-4,Issue 1, April 2010.

[10] Ahmed A. Abdulfetah, Xingming Sun,Hengfu Yang,and Nur Mahammad "Robust Adaptive Image Watermarking using Visual Models in DWT and DCT domain", Information Technology Journal 9(3):460-466,2010.

[11] Tao Zhang, Daoshun Wang, Shundong Li, Xunxue Cui, Yiqi Dai "Adaptive attacking algorithm against DCT-based watermarking" Proceeding of the 11th Joint Conference on Information Science 2008.

[12] Yhya. R. Kuraz, Modar A.H. "Improve Watermark Security Via Wavelet Transfrom And Cdma Techniques" Al-Rafidain Engineering, Vol.16,No.3, Aug. 2008.

[13] Baisa L. Gunjal, R.R. Manthalkar "AN OVERVIEW OF TRANSFORM DOMAIN ROBUST DIGITAL IMAGE WATERMARKING ALGORITHMS" Journal of Emerging Trends in Computing and Information Sciences, Volume 2 No. 1,2010-11.

[14] V.Santhi and Dr. Arunkumar Thangavelu "DWT-SVD Combined Full Band Robust Watermarking Technique for Color Images in YUV Color Space" International Journal of Computer Theory and Engineering, Vol. 1, No. 4, October 2009.

[15] Chu-Hsing Lin, Jung-Chun Liu, Chih-Hsiong Shih, Yan-Wei Lee "A Robust Watermark Scheme for Copyright Protection" International Conference on Multimedia and Ubiquitous Engineering, 2008.

[16] Rashmi Agarwal K. Venugopalan "Digital Watermarking of Color Images in the Singular Domain" IJCA Special Issue on "Computational Science - New Dimensions & Perspectives" NCCSE, 2011