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A ROBUST METHOD FOR DIGITAL IMAGES WATERMARKING BASED ON COMBINATION OF SVD, DWT AND DCT USING OPTIMAL BLOCK

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ABSTRACT
With the growth of the Internet, development of digital media technologies and computer network, the change and the protection of copyright have become very important. To protect multimedia data against illegal recording and retransmission, the integration of a signal (digital signature, watermark) has become an obligation without modifying quality of the original image, the goal of this operation is to identify the owner and protect his intellectual property. Digital watermarking has been proposed as a solution to solving the copyright problem by introducing invisible data (watermark) into original image. In this paper, we propose a robust method for digital images watermarking. This method is achieved by searching the optimal block that can be used to insert the watermark in original image by modifying the singular value decomposition (SVD) in DWT (discrete wavelet transform) combined with DCT (Discrete Cosine Transform) . The experimental results show that this imperceptible method combines the advantage of three transformations to ensure robustness against most attacks.

Keywords: *Watermarking, DWT, SVD, DCT, Entropy*

1. INTRODUCTION

The World Wide Web has evolved significantly in different areas, especially multimedia technologies, involving extensive use of digital data such as images and videos. The information that vehicle in this world is a large database that requires an efficient way to meet the intellectual property [1-2]; this condition has become an important factor in the emergence of this technology. The digital image watermarking has been a reliable way to ensure that intellectual property [3-4]. Digital watermarking has many applications in several areas, such as the application of copyright protection, authentication, and secret communication [5]. Digital image watermarking means a discipline of applied mathematics that studies the digital images and their transformations in order to improve their quality or to extract information [6-7]. This discipline involves inserting an invisible mark (digital signature) in an image or other digital documents. The inserted mark must be known by the owner or the distributor, and it must meet three basic requirements: imperceptibility, robustness and capacity [8-9]. Imperceptibility means that the deformation of the image must be low enough that the user cannot distinguish the difference between the watermarked image and the original image [10]. The robustness is the power to recover the inserted even if the watermarked image was manipulated by attacks [11]. Capacity of the watermarking system is defined as the maximum amount of information that can be embedded in the original image [12].

These constraints must come together to create a scheme of a system for watermarking images that can be described insertion and extraction of the mark. This scheme should be have a good robustness against conventional and geometrical attacks [13].

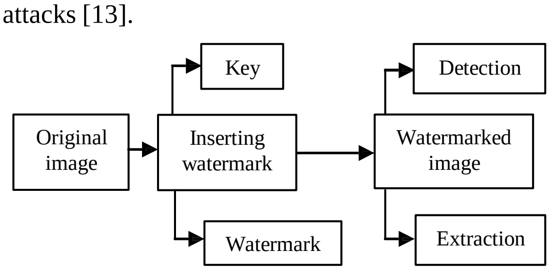

Figure 1: standard watermarking scheme

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In this study we present a robust method of watermarking based on optimal block selected by the level value of entropy [14,15], then we make modification in singular value decomposition (SVD) of this bloc after the application of DWT combined with DCT, to ensure the robustness and imperceptibility of our watermarking scheme.

This paper will be organized as follows. Section 2 illustrates the decomposition techniques of images processing. Section 3 presents the proposed method watermarking scheme in detail. Section 4 clarifies experiment results as well as some discussions. Conclusions are given in section 5.

2. DECOMPOSITION TECHNIQUES OF IMAGES PROCESSING

We know that the goal of watermarking is insertion of secret information that will be difficult to extract, for this we will need to insert in specific parts of the image. To find these parts there are various techniques of decomposition [16] and transformation as DCT, DWT, SVD, so on.

2.1 Discrete Cosine Transform

DCT is a transformation function used in signal processing. It transforms a signal from the spatial domain to the frequency domain. Its performance allows it to be used in the JPEG standard for image compression. DCT is been applied in many areas such as data compression, pattern recognition image processing and so on [17, 18]. The DCT and its inverse manner can be expressed as follows:

$$DCT(i,j) = \frac{1}{\sqrt{2N}} B(i)B(j) \sum_{x=0}^{N-1}\sum_{y=0}^{N-1} M(x,y)$$

$$.\cos\left[\frac{(2x+1)}{2N} i\pi\right] \cos\left[\frac{(2y+1)}{2N} j\pi\right]$$

Where

M(x,y) is the original data of size $x \times y$

$$B(u) = \begin{cases} \frac{1}{\sqrt{2}} & \text{if } (u = 0) \\ 1 & \text{if } (u>0) \end{cases}$$

The corresponding inverse transformation (Whether 2D IDCT) is defined as:

$$M(x,y) = \frac{1}{\sqrt{2N}} B(i)B(j) \sum_{x=0}^{N-1}\sum_{y=0}^{N-1} DCT(i,j)$$

$$.\cos\left[\frac{(2x+1)}{2N} i\pi\right] \cos\left[\frac{(2y+1)}{2N} j\pi\right]_{\mu}$$

$$B(u) = \begin{cases} \frac{1}{\sqrt{2}} & \text{if } (u = 0) \\ 1 & \text{if } (u>0) \end{cases}$$

2.2 Discrete Wavelet Transform

DWT is a method for analyzing multi-level signal [19, 20]; it can analyze the signal at different frequency bands with different resolutions by decomposing it into approximation and detailed information.The principle of the algorithm is to divide the image into four at each iteration, three blocks on the details of the image (LH, HL, HH), and the fourth (LL) corresponds to the most important information for the eye (low frequencies), which serves basis for the next iteration [21, 22].

To decompose this image into sub image we use: high and low pass filters.

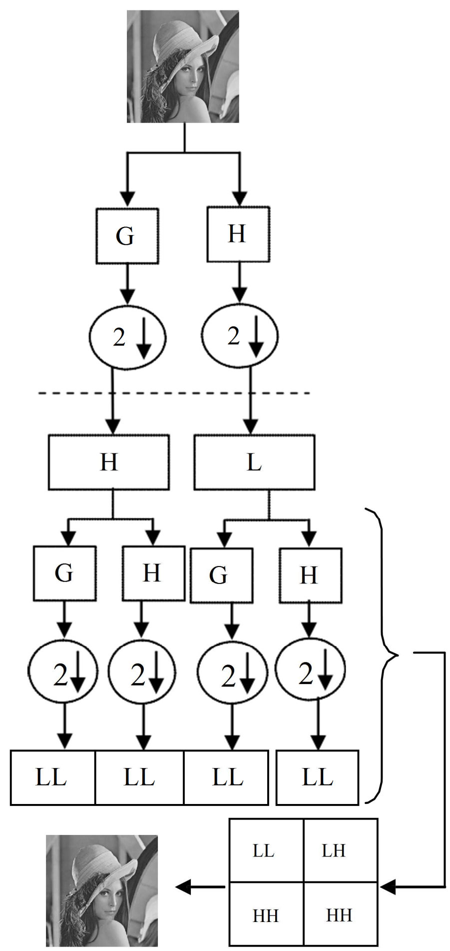

Figure2: Discrete Wavelet Transform

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2.3 SVD based watermarking

Singular value decomposition (SVD) is a numerical analysis tool used to diagonalize matrices. It is developed for a variety of applications algorithm. The main properties of the SVD in terms of image processing applications are: Singular values (SVs) of the image have very good stability to know when a small perturbation is made in the image of the SV does not change significantly; SV is an algebraic intrinsic property. SVD processing in a matrix A can be decomposed into three matrices of the same size as the initial matrix; two orthogonal matrices U and V and a diagonal matrix S [23].

$$A = U * S * VT$$

The columns of U and V are called respectively left and right singular vectors of A. They essentially determine the details geometry of the original image. The diagonal values of the matrix S are ranked in descending order. [24]

$\sigma 1 \geq \sigma 2 \geq \sigma 3 \geq \ldots\ldots\ldots \sigma r \geq \sigma r{+}1 \geq = \ldots\ldots \sigma n = 0$

$$\begin{bmatrix} \sigma 1 & . & . & 0 & 0 & 0 \\ 0 & \sigma 2 & 0 & 0 & 0 & 0 \\ . & . & . & . & . & . \\ . & . & . & \sigma_r & 0 & 0 \\ . & . & . & . & . & 0 \\ 0 & 0 & 0 & 0 & 0 & \sigma_n \end{bmatrix}$$

2.4 Entropy

Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image. Entropy is defined as:

E=-sum(p.*log2(p))

Where p contains the histogram counts returned from imhist. By default, entropy uses two bins for logical arrays and 256 bins for uint8, uint16, or double arrays. [25]

3. PROPOSED METHOD

The proposed algorithm combines the properties of DWT, DCT and SVD techniques to increase the robustness and capacity of the algorithm by selecting specifics blocks which have the maximum entropy value.
The procedure for embedding the watermark is given below.

3.1 Watermark embedding process

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

Step 1: apply DWT on the original image to decompose it into 64x46 sub-bands LL2, LH2, HL2, and HH2.

Step 2: devising image into different blocks (sub-images) and calculate the entropy of each block. After we select the block which has the maximum entropy from LH and HH sub-bands, then we applied DCT to it and get DCT coefficient matrix A and D.

Step 3: apply SVD to A and D.
$A = U_a * S_a * V^T$;
$D = U_d * S_d * V_d^T$.

Step 4: apply DWT on the watermark image.

Step 5: apply SVD to HH sub band to get B matrix,
$B_w = U_w * S_w * V^T$.

Step 6: modify S_a with watermark such that
$S2 = S_a + \alpha S_w$.

Step 7: modify S_d with watermark such that
$S2 = S_a + \alpha S_w$;

Step 8: obtain A*, $A^* = U_a * S2 * V_a^T$.
obtain D*, $D^* = Ud * S3 * V_d^T$.

Step 9: Apply inverse DCT to obtain LH* and HH*.

Step10: Apply inverse DWT to LL, LH*, HL, HH*.

Step11: obtain the watermarked image.

These steps are described with this scheme.

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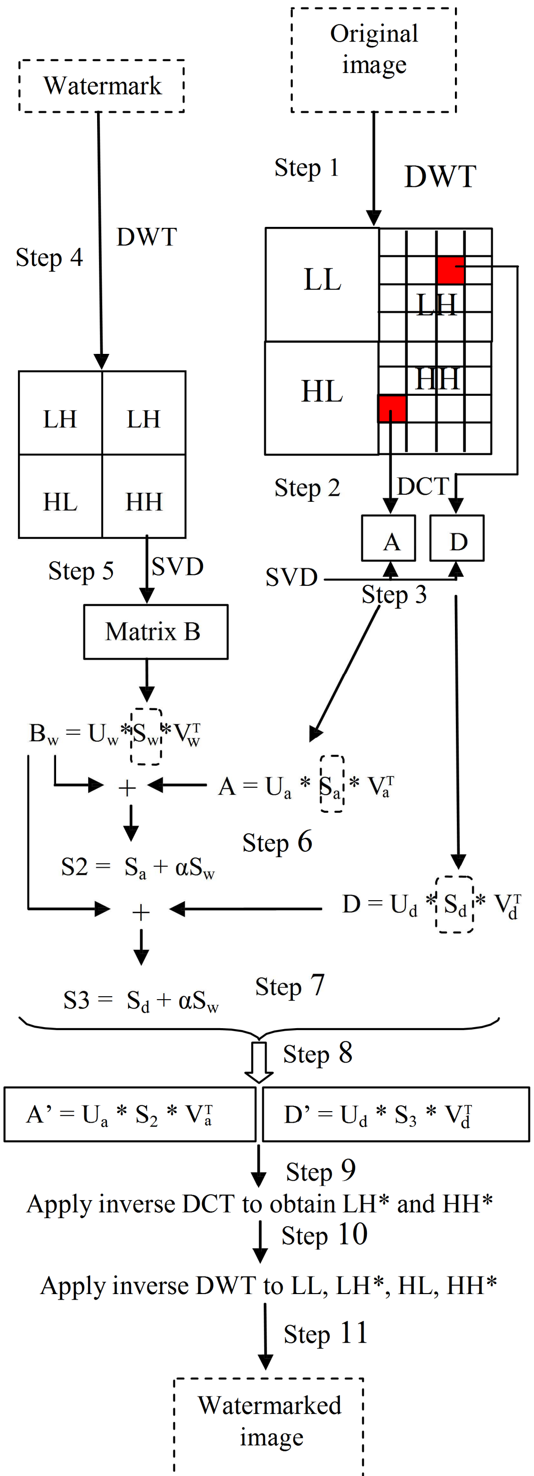


Figure3: watermark embedding process

3. EXPERIMENTAL RESULTS

The robustness is tested under 9 types of attacks: Salt and pepper, Gaussian noise, median filtering, resizing, contrast adjustment, JPEG compression, cropping, and rotation, Histogram equalization. The watermarked image and Extracted Watermark with and without attacks are shown in Figure 5 and 6.

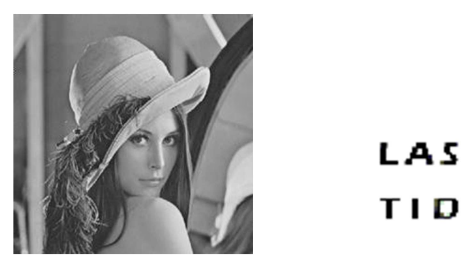
The original image considered for the experimentation is 512 x 512 Lena. The watermark image is of 32 x 32 sizes which is a logo as shown in Figure4. Figure5 indicates that visual appearance of the watermarked image is good with a PSNR of **58.049 dB.** The metrics used to assess the performance of the proposed algorithm are PSNR and NC (between original and watermarked image to improve the imperceptibility).

Normalized Correlation Coefficient is defined as follows:

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

PSNR (peak to signal-to-noise ratio) is defined as follows:

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right)$$



Original image Watermark

Figure4: original image and watermark

Watermarked image 512x512 PSNR= **58.049 dB**
NC=1

Extracted watermark in LH

Extracted watermark in HH

Figure5: watermarked image and extracted watermark

The results of different attacks are given as bellow:

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(a) (b) (c)

PSNR= **25.1990 dB**
NC=**1**

Salt and pepper noise (0.01 density)

(a) (b) (c)

PSNR=**12.5311 dB**
NC=**0.9107**

Resizing

(a) (b) (c)

PSNR= **11.2633 dB**
NC=**1**

Rotation (20^0)

(a) (b) (c)

PSNR=**20.4928 dB**
NC=**1**

Contrast adjustement

(a) (b) (c)

PSNR= **19.7690 dB**
NC=**1**

Gaussian noise

(a) (b) (c)

PSNR=**12.5989 dB**
NC=**1**

Cropping 25%

(a) (b) (c)

PSNR= **25.5455 dB**
NC=**0.9896**

Median filtering (3x3) kernel

PSNR=**29.4579 dB**
NC=**0.9999**

JPEG QF=70

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(a) (b) (c)

PSNR=**28.4359 dB**
NC=**1**
Histogram equalization

Figure 6(a).Attacked watermarked image with PSNR and NC.
(b).Extracted watermark from LH matrix.
(c).Extracted watermark from HH matrix.

These results are resumed in table and graphs as bellow:

Table1: PSNR and NC of original and watermarked image after various attacks

Attacks	***PSNR***	***NC***
Without attack	58.049	1
Salt and pepper noise (0.01 density)	25.1990	1
Rotation (20^0)	11.2633	1
Gaussian noise	19.7690	1
Median filtering (3x3) kernel	25.5455	0.9896
Resizing	12.5311	0.9107
Contrast adjustement	20.4928	1
Cropping 25%	12.5989	1
Histogram equalization	28.4358	1
JPEG QF=70	29.4579	0.9999

4. CONCLUSION

In this paper a robust watermarking method for copyright protection has been proposed. This method based on combination of three transformations DCT, DWT, SVD using optimal block ensure the criteria of digital image watermarking, robustness, imperceptibility and capacity. The experimental results show that this method is robust against most attacks. Thereby we can conclude that intellectual property of images is protected by our approach.

REFRENCES:

[1] M. Natarajan and Gayas Makhdumi, and D.P. Kothari, "Safeguarding the Digital Contents: Digital Watermarking", DESIDOC Journal of Library & Information Technology, Vol. 29, No. 3, May 2009, pp. 29-3.

[2] Mahmoud Elnajjar, A.A Zaidan, B.B Zaidan, Mohamed Elhadi M.Sharif and Hamdan. O.Alanazi, "Optimization Digital Image Watermarking Technique for Patent Protection", JOURNAL OF COMPUTING, VOLUME 2, ISSUE 2, FEBRUARY 2010, ISSN 2151-9617.

[3] Christian S. Collberg, Member, IEEE Computer Society, and Clark Thomborson, Senior Member, IEEE, "Watermarking, Tamper-Proofing, and Obfuscation–Tools for Software Protection", IEEE TRANSACTIONS ON SOFTWARE ENGINEERING, VOL. 28, NO. 8, AUGUST 2002.

[4] Yusuf Perwej, Firoj Parwej, Asif Perwej, "An Adaptive Watermarking Technique for the copyright of digital images and Digital Image Protection", The International Journal of Multimedia & Its Applications (IJMA) Vol.4, No.2, April 2012.

[5] S. Radharani, Dr. M.L. Valarmathi, "Multiple Watermarking Scheme for Image Authentication and Copyright Protection using Wavelet based Texture Properties and Visual Cryptography", international Journal of Computer Applications (0975 –8887) Volume 23–No.3, June 2011.

[6] Vandana Sthul, Prof. N. N. Khalsa, "Digital watermarking of an image using wavelet transform", international journal of pure and applied research in engineering and technology, Vandana Sthul, IJPRET, 2013; Volume 1(8):365-378.

[7] Keshav S. Rawat, Sachin Goyal and Roopam Gupta, "Discrete wavelet based image watermarking: An idea leads to security", Journal of Biom etrics, Vol. 1, Issue 1, 2010, pp-06-10.

[8] Chandan Singh, Sukhjeet K. Ranade, "An Effective Image Watermarking System for High Embedding Capacity", Proceedings published in International Journal of Computer Applications (IJCA).

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[9] Tse-Hua Lan , Member, IEEE, and Ahmed H. Tewfik, Fellow, IEEE, "A Novel High-Capacity Data-Embedding System", IEEE RANSACTIONS ON IMAGE PROCESSING, VOL. 15, NO. 8, AUGUST 2006.7

[10] Hong-Mei Yang, Yong-quan Liang, Xiao-Dong Wang ; Shu-juan Ji, "A DWT- based evaluation method of imperceptibility of watermark in watermarked color image", Wavelet Analysis and Pattern Recognition, 2007. ICWAPR '07. International Conference on (Volume:1), pp-198-203.

[11] Frank Hartung, Student member, IEEE, and martin kutter, Multimedia Watermarking Techniques, proceddings of the IEEE, VOL. 87, NO. 7, JULY 1999.

[12] Prabhishek Singh, R S Chadha, "A Survey of Digital Watermarking Techniques, Applications and Attacks", International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 9, March 2013.

[14] Mohamed RADOUANE, Tarik BOUJIHA, Rochdi MESSOUSSI, Nadia IDRISSI, Ahmed ROUKH, "A Method of LSB substitution based on image blocks and maximum entropy", IJCSI International Journal of Computer Science Issues, Vol. 10, Issue 1, No 1, January 2013.

[15] Nadia IDRISSI, Ahmed ROUKH, Lhoussaine MASMOUDI, Mohamed RADOUANE, Rochdi MESSOUSSI, "A Robust Digital Watermarking Technique using DWT-DCT and Statics blocks", IJCSI International Journal of Computer Science Issues, Vol. 10, Issue 2, No 1, March 2013.

[16] Aree Ali Mohammed, Haval Mohammed Sidqi, "Robust Image Watermarking Scheme Based on Wavelet Technique", International Journal of Computer Science and Security (IJCSS), Volume (5) : Issue (4) : 2011.

[17] Md. Maklachur Rahman, "A DWT, DCT AND SVD BASED WATERMARKING TECHNIQUE TO PROTECT THE I MAGE PIRACY" International Journal of Managing Public Sector Information and Communication Technologies (IJMPICT) Vol. 4, No. 2, June 2013.

[18] Vijaya K. Ahire†, Vivek Kshirsagar, "Robust Watermarking Scheme Based on Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT) for Copyright Protection of Digital Images", IJCSNS International Journal of Computer Science and Network Security, VOL.11 No.8, August 2011.

[19] Mei Jiansheng, Li Sukang and Tan Xiaomei, "A Digital Watermarking Algorithm Based On DCT and DWT", Proceedings of the 2009 International Symposium on Web Information Systems and Applications (WISA'09) Nanchang,P.R. China, May 22-24, 2009, pp. 104-107.

[20] Nikita Kashyap, G. R. SINHA, "Image Watermarking Using 3-Level Discrete Wavelet Transform (DWT)", I.J.Modern Education and Computer Science, 2012, 3, 50-56 Published Online April 2012 in MECS, DOI: 10.5815/ijmecs.2012.03.07.

[21] AYANGAR, V.R, TALBAR, S.N, "A NOVEL DWT-SVD BASED WATERMARKING SCHEME", MULTIMEDIA COMPUTING AND INFORMATION TECHNOLOGY (MCIT), 2010 INTERNATIONAL CONFERENCE ON , pp-105-108.

[22] Tanmay Bhattacharya, Nilanjan Dey, S. R. Bhadra Chaudhuri, "A Session based Multiple Image Hiding Technique using DWT and DCT", International Journal of Computer Applications (0975 –8887) Volume 38–No.5. January 2012.

[23] SATYANARAYANA MURTY. P, M.UDAY BHASKAR, P. RAJESH KUMAR, "A SEMI-BLIND REFERENCE WATERMARKING SCHEME USING DWT-DCT-SVD FOR COPYRIGHT PROTECTION", INTERNATIONAL JOURNAL OF COMPUTER SCIENCE & INFORMATION TECHNOLOGY (IJCSIT) VOL 4, NO 2, APRIL 2012.

[24] Ms. N.Singh, Mr. M.M.Sharma, "SINGULAR VALUE DECOMPOSITION TECHNIQUE OF DIGITAL IMAGE WATERMARKING", National Conference on Advancements in Wireless and Optical Communication Technologies-2010.

[25] Acta Applicandae Mathematicae, Zouhir Mokhtari, Khaled Melkemi, A New Watermarking Algorithm Based on Entropy Concept, Volume 116, Issue 1, pp 65-69, Octobre 2011.