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Invisible Watermarking of Color Images using SVD and DWT

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Abstract—The rapid growth of the world wide web and the wide spread usage of multimedia in the internet has resulted in various security and authenticity issues. Everyday multimedia content is shared via internet to different locations and different people across the globe. The various image processing techniques available today allows intellectual property theft and reproduction of digital images in an unauthorized way. This has given rise to the need to protect copyright of digital images. Protection of copyright of the digital image is done through the process of water marking. This process embeds an authentication mark (water mark image) into the actual image that is transmitted over the internet (cover image) to avoid unauthorized reproduction of the digital images. In this paper, an effective and robust invisible water making method is proposed using the Discrete Wavelet Transform (DWT) and Singular value Decomposition (SVD).

Keywords—authentication; copyrightprotection; robustness; discrete wavelet transform; singular value decomposistion.

I. INTRODUCTION

With the enormous usage of multimedia and its widespread distribution over the internet networks, it has become easy to obtain the intellectual properties. Consequently, the multimedia owners need more than ever before to protect their data and to prevent the unauthorized use of their data. Traditionally encryption and access control techniques have been used for ownership protection; but these techniques do not protect the ownership of the data after the multimedia have been received and decrypted successfully. A subsequent technique to protect the ownership rights is watermarking. It is a technique for hiding the owner's information in the multimedia to provide a proof of ownership. It also provides a solution for copyright protection, unauthorized manipulation of the multimedia, image authentication, tamper detection and broadcast monitoring etc.

In general, embedding of the watermark and its detection process is described as follows. The owner of the original data embeds a secret authentication mark (watermark) onto the original data to produce a watermarked image. The owner keeps the original data and the original watermark hidden and publishes the watermarked data. The two types of digital watermarking are visible and invisible watermarking.

- **Visible Watermark:** It is a translucent image, which is placed on the cover image and is visible.

- **Invisible Watermark:** This watermark is embedded into the cover image which is not visible can only be detected only after processing the cover image using a specific algorithm.

The either case the watermark should be robust to any kind of attacks or destruction. In case of suspected misappropriation only then the ownership could be verified, even when the image is subjected to any kind of attacks. For a watermark to be effective, it should satisfy the following features:

- **Invisibleness**: It refers to the perceptual similarity between the original and watermarked data.
- **Robustness:** It means that the watermarking scheme employed should be able to preserve the watermark under various attacks.
- **Unambiguous:** The extracted watermark should identify the owner without any ambiguity.

A digital invisible watermark has a little trade off in satisfying the invisibleness and robustness features. Because, to get the watermarking scheme with high robustness, it requires stronger embedding, this in turn reduces the invisibleness. So, this paper offers an invisible watermarking scheme using SVD and DWT algorithms. The remaining part of the paper is structured as follows: Section II gives the review of related works, Section III explains the theoretical background of algorithms, Section IV describes the proposed method, Section V discusses the experimental results and finally Section VI concludes the paper.

II. RELATED WORKS

There are a numerous number of watermarking techniques in literature. The authors in [1] argue that generating an infinite number of discrete bi-orthogonal wavelets starting from an initial one, singular values (SV) allow to make changes in an image. The authors in [2] have proposed a block based blind image watermarking using DWT and SVD. A watermarking scheme using singular value decomposition based on linear algebra techniques is proposed in [3]. A hybrid watermarking algorithm that uses the DWT-DCT-SVD algorithms is discussed in [4] whereas a hybrid watermarking scheme using SVD and DWT, where the watermark is embedded in singular value decomposition of the red component of cover image is explained in [5].

The watermarking algorithm in [6] uses DWT, DCT and SVD transformation and all high bands LH, HL and HH are chosen to embed the watermark. The authors in [7] have proposed a digital watermarking algorithm based on DWT-DCT-SVD and Arnold transform. In the work [8], using wavelet transform the cover image is decomposed into different frequency sub bands. Then block based DCT is applied to compute the singular values from the DC values of all blocks to insert the watermark. In [9], [10] SVD algorithm is applied both to the cover and watermark image and the singular values of watermark is embedded on the singular values of the cover image. In [11] the location to embed the watermark is identified by comparing the energy value of low frequency sub-band in the transformed blue channel and green channel component. Discrete wavelet transform is applied up to three levels in [12], and the horizontal band is used to embed the watermark on the singular values of the cover image. DCT coefficients which are obtained from the middle frequency sub-band DWT coefficients of the cover image are used in [14] to embed DCT transformed watermark image coefficients. In [14], the blue channel of the cover image is used to embed the watermark using SVD.

III. THEORITICAL BACKGROUND

Discrete Wavelet Transform

When DWT is applied on an image, it divides the image in frequency components. Using low-pass and high-pass filters the image is decomposed both along the horizontal and vertical directions and this produces four sub-bands: an approximation sub-band (LL), and three detail sub-bands (LH, HL and HH). The low frequency components (LL) are approximate coefficients holding almost the original image and high frequency components (LH, HL, HH) are detailed coefficients holding additional information about the image. These detailed coefficients can be used to embed secret image. The approximation sub-band (LL) is used to obtain the sub-bands at the next level of decomposition.

Singular Value Decomposition

Singular value decomposition is a fundamental mathematical analysis tool used to analyze matrices; it provides a convenient way for breaking a matrix, which perhaps contains some data we are interested in, into simpler, meaningful pieces. It is an optimal decomposition system and it bundles the maximum signal energy into few of coefficients [15, 16]. It has been widely and successfully used in various applications, such as multimedia signal processing, pattern recognition and data compression. The singular value decomposition of a matrix A is the factorization of A into the product of three matrices

$$A = UDV^T$$

where the columns of *U* and *V* are orthonormal and the matrix D is diagonal with positive real entries. The columns of *U* are the left singular vectors of the matrix *A*, and the columns of *V* are the right singular values of matrix *A*.

SVD has many good mathematical characteristics.

- The matrices obtained from SVD transformation need not be square matrix or fixed. It can either be a square or a rectangle.
- Even when a small perturbation is added to an image; its SVs do not vary rapidly and thus SVs (Singular Values) of an image have very good stability.
- To protect the embedded water mark from affine distortions secret image is hidden into singular values of high frequency coefficients.

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IV. PROPOSED WORK

The block diagram of the proposed robust invisible watermark embedding and extracting method is depicted in Fig. 1 and Fig. 2.

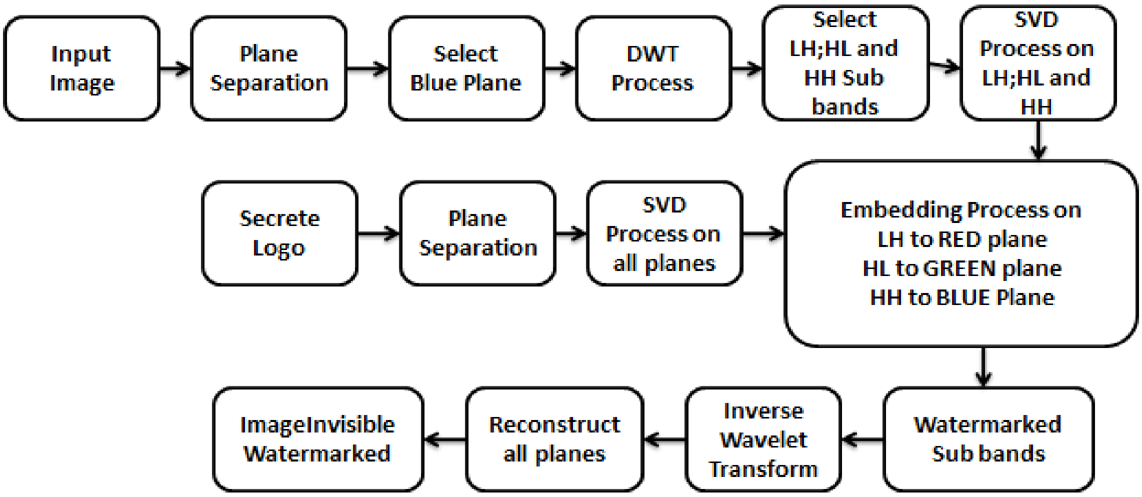

Fig. 1 Steps in watermark embedding process

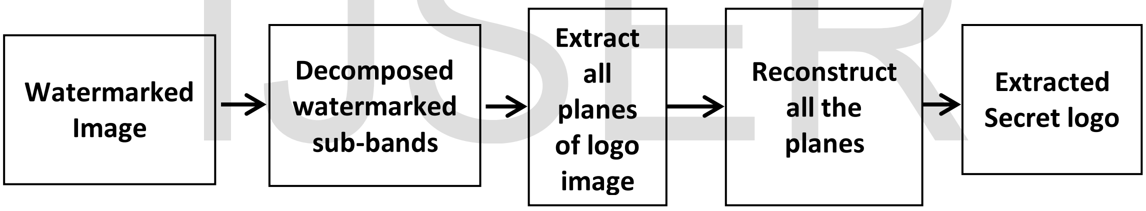

Fig. 2 Steps in watermark extraction process

This is based on DWT and SVD. The R, G, B planes of the original image in which the watermark is to be embedded is first separated. The blue plane alone is considered for embedding the watermark. For this, discrete wavelet transformation and singular value decomposition is applied on the blue plane. Then the singular values of the different sub-band coefficients of the blue channel are modified using one least factor called alpha factor for embedding the singular values of the watermark

A. *Proposed Watermark Embedding Process*

The steps are:

- The cover image is separated into The Red, Green and Blue planes.
- DWT is applied to the blue plan alone to get the LL, LH, HL and HH sub-bands.

- Then SVD is applied on LH HL HH sub-bands and the U,S and V matrix that are obtained are used to embed the watermark.
- SVD is applied on all the three: R,G and B planes of the watermark image (secret logo).
- The singular values of watermark image is then embedded onto the singular values of cover image using the alpha factor (Controlling parameter for the watermark to embed).
- The embedded watermarked image is then reconstructed using inverse DWT and combining all the planes together.
-

B. Proposed Watermark Extraction Process

The steps are

- The watermarked image is separated into The Red, Green and Blue planes.
- The blue plane is selected and DWT is applied to obtain LH, HL and HH sub-bands.
- SVD is applied to LH, HL and HH sub-bands to get singular value matrix S from sub-bands.
- The watermark is retrieved from the singular values using the alpha factor.
- Retrieved watermark is reconstruct by combining all the planes

V. Experimental Results and Discussion

The experiments are carried out varying the alpha factor from 0.01 to 0.07 with a constant interval of 0.02. The metrics namely Peak-Signal-to-Noise-Ratio (PSNR in dB) and Mean Squared Error (MSE) are used to measure the invisibleness and robustness of the proposed method.

A. Performance Measures

In general Peak Signal to Noise Ratio (PSNR) and Mean Squared Error (MSE) are the two error metrics that are used to assess the quality of an image.

PSNR is the ratio between the maximum power of a signal to the maximum power the noise and its unit is decibels.

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

MSE is an error metric that gives the cumulative suareed error between two images

$$MSE = \left(\frac{1}{M \times N}\right) * \sum_{M,N}\left[f(m,n) - g(m,n)\right]^2$$

where,
f - original image
g - watermarked image
m - the numbers of rows
n - the number of columns

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MAX - the maximum signal value that exists in the original image.

The higher the value of PSNR, better the quality of the image and lower the value of MSE, the lower is the error.

B. *Results and Discussion*

The sample cover and watermark images are of resolution 256×256 pixels and 128×128 pixels respectively. Fig.3 a) and Fig.3 b) shows the sample cover and watermark images. The performance namely invisibleness and robustness for different alpha values are evaluated and is provided in the Table I and Table II.

a) Cover image b) Watermark image

Fig. 3 Sample Input

It can be seen from the Table I that the value of PSNR is high and the value of MSE is low for the alpha factor 0.01 when compared to the other alpha factors. Similarly, it can be seen from the Table II that the value of PSNR is high and the value of MSE is low for the alpha factor 0.01 when compared to the other factors. So, it is clear that the invisibleness and robustness of the proposed method is good with the alpha factor 0.01. It is also graphically shown in the Fig.4 to Fig.7.

Table I: MSE AND PSNR as a metric for invisibleness with different alpha factors

Alpha factor values	*MSE*	*PSNR*
.01	3.09	43.21
0.03	12.8	33.68
0.05	17.3	29.24
0.07	21.6	26.31

Table II: MSE AND PSNR as a metric for robustness with different alpha factors

Alpha factor values	*MSE*	*PSNR*
0.01	8.23	33.72
0.03	15.01	30.95
0.05	16.80	28.74
0.07	21.35	27.27

The GUI showing the results and performance of the proposed work is shown in Fig. 8 and Fig. 9

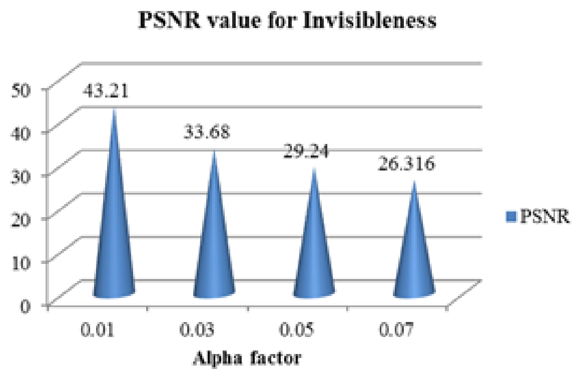

Fig. 4 Performance of Invisibleness using PSNR

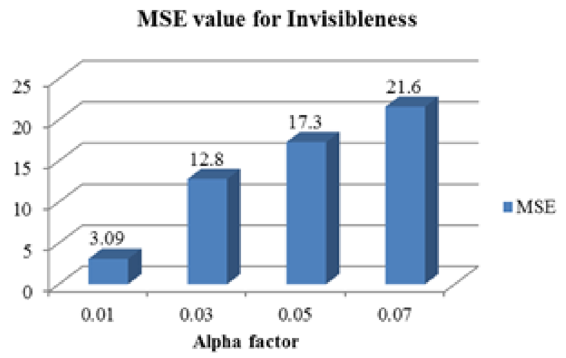

Fig. 5 Performance of Invisibleness using MSE

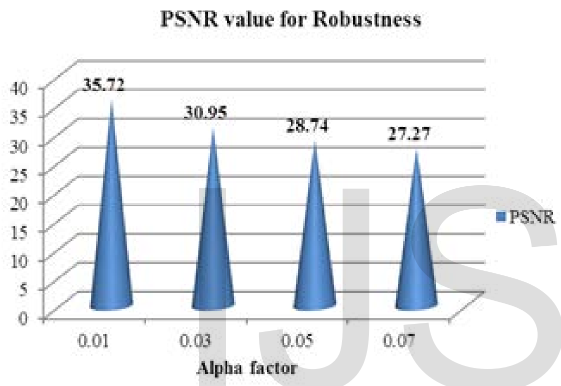

Fig. 6 Performance of Robustness using PSNR

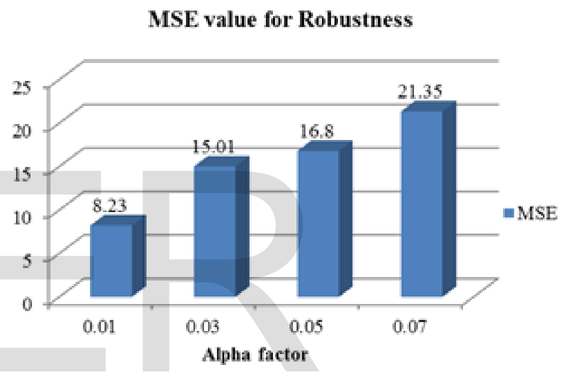

Fig. 7 Performance of Robustness using MSE

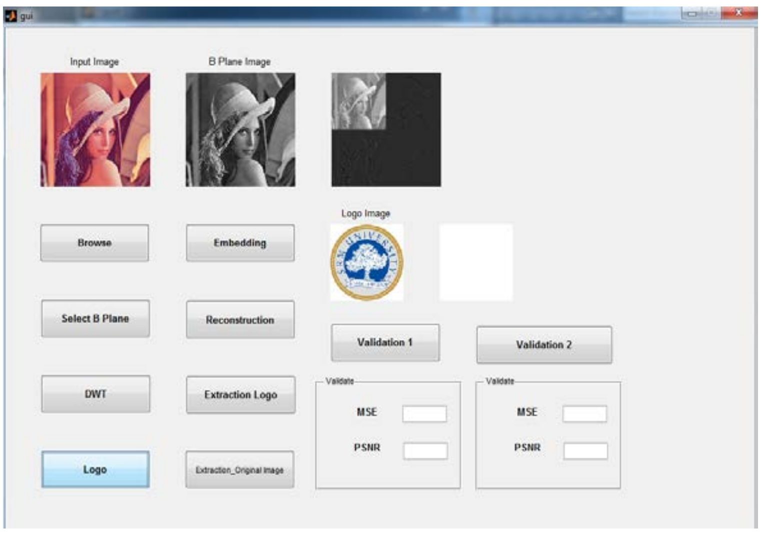

Fig. 8 Validation of invisibleness

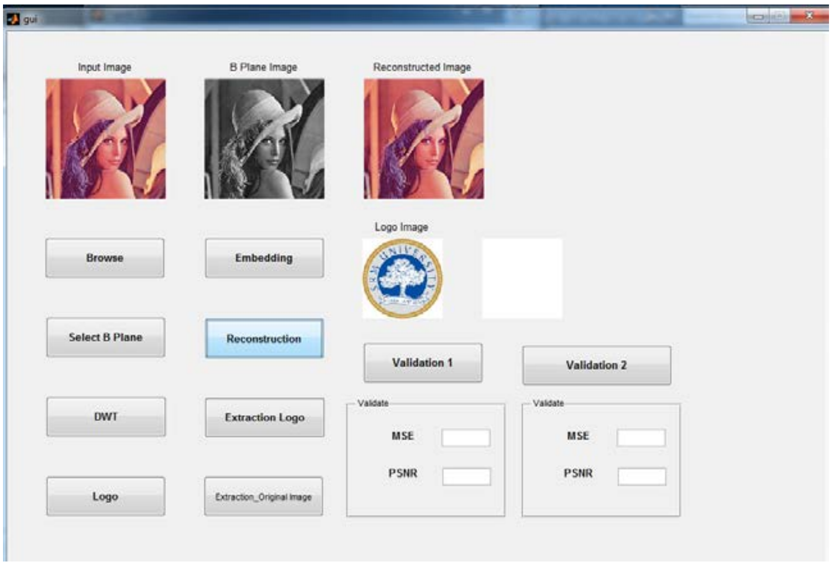

Fig. 9 Validation of Robustness

VI. CONCLUSION

This proposed invisible colour image watermarking scheme using DWT and SVD was successfully implemented and the invisibleness and robustness of the scheme was also analyzed. . In this experiment, SRM university logo is used as watermark to embed onto the cover image. Watermark embedding process is carried out using various alpha factors from 0.01 to 0.07 with a constant interval of 0.02. The invisibleness and robustness of proposed watermarking system where evaluated using the quality metrics PSNR and MSE and it produced a good result with the alpha factor 0.01.

REFERENCES

[1]. M. S. Arya, R. Siddavatam, and S. Ghrera, “A hybrid semi-blind digital image watermarking technique using lifting wavelet transform Singular value decomposition,” IEEE International Conference on Electro/Information Technology(EIT), pp.1-6, 2011.

[2]. Krishna Rao Kakkirala and Srinivasa Rao Chalamala “Block Based Robust Blind Image Watermarking Using Discrete Wavelet Transform”, IEEE 10th International colloquim on signal processing and its application (CSPA2014) 7-9 Mac 2014 Kuala lumphur Malasiya

[3]. K. Chaitania “Digital Color Image Watermarking In RGB Planes Using DWT-DCT-SVD Coefficient ”K.chaitania et al./(IJCSIT) International Journal of Computer science and informationTechnologies,Vol.5(2),2014,2413-2417

[4]. Satyanarayana Murthy “A Robust Digital Image Watermarking Scheme Hybird DWT-DCT-SVD Technique” (IJCSNS) International Journal of Computer and Network Security,Vol.10 No.10.Oct 2010

[5]. Jaishri Guru "A Fusion of DWT and SVD Digital Watermarking Techniques for Robustness" (IJARCSSE) International Journal of Research in Computer science and Softwere Engineering Vo. l.4, Issue.9, September 2014.

[6]. Md.Maklachur Rahman "A DWT-DCT and SVD Based Watermarking Technique To Protect The Image Piarcy"(IHMPICT) International Journal of Managing Public Sector Information and Communication Technologies Vol.4,No.2,June 2013

[7]. Hasan Demirel ."IMAGE Resonation Enhancement by Using Discrete and stationary Wavelet Decomposition"(IEEE) Transaction on Image Processing.Vol.20,No.5,May 2011

[8]. Santhi V, Thangavelu DA. DC Coefficients Based Watermarking Technique for color Images Using Singular Value Decomposition. International Journal of Computer and Electrical Engineering., vol.3 (1):1793–8163, 2011.

[9]. Kumari VV, Chitra B. Comparison of SVD Based Image Watermarking Techniques Implemented for Gray Scale and Color Images. International Journal of Machine Intelligence,vol. 3, 2011.

[10]. Dogan S, Tuncer T, Avci E, Gulten A. A robust color image watermarking with Singular Value Decomposition method. Advances in Engineering Software. Elsevier; vol. no. 42(6):336–346, 2011.

[11]. Gao H, Jia L, Liu M. A digital watermarking algorithm for color image based on DWT. TELKOMNIKA Indonesian Journal of Electrical Engineering. 2013, vol.11 (6):3271–3278.

[12]. Gunjal BL, Mali SN. Comparative performance analysis of DWT-SVD based color image watermarking technique in YUV, RGB and YIQ color spaces. International Journal of Computer Theory and Engineering, vol.3 (6):714–717, 2011.

[13]. Eswaraiah R, Reddy ES. Robust Watermarking Method for Color Images Using DCT Coefficients of Watermark. Global Journal of Computer Science and Technology, vol.12 (12-F) 2012.

[14].D. Vaishnavi, T.S. Subashini, Robust and Invisible Image Watermarking in RGB Color Space Using SVD, Procedia Computer Science, Volume 46, Pages 1770-1777, 2015.

[15]. V.C. Klema and A.J. Laub, "The singular value decomposition: Its computation and some applications," IEEE Trans. Autom. Contr., vol. AC-25, no. 2, pp. 164-176, Apr. 1980.

[16]. H. Yanai, K. Takeuchi, and Y. Takane, Projection Matrices, Generalized Inverse Matrices, and Singular Value Decomposition. New York: Springer Science and Business Media, 2011.