

A Hybrid DCT- SVD Based Robust Watermarking Scheme for Copyright Protection

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Abstract—A hybrid watermarking scheme exploiting the properties of the Discrete Cosine Transform (DCT) and Singular Value Decomposition(SVD) has been proposed here. A reference image is being formed from the cover image and then its singular values are modified to hide the secret information in an imperceptible way. The security is further enhanced by the zig zag scrambling of the cover image and gray scale watermarks. The robustness of the methodology against the various image processing attacks has been validated with high Normalized Cross Correlation (NCC) values. Also, the imperceptibility of the watermarked image with the original cover image comes out to be high as indicated by high achievable Peak Signal to Noise Ratio (PSNR) values. instructions give you guidelines for preparing papers for conferences

Keywords—Discrete Cosine Transform (DCT), Normalized Cross Correlation(NCC), Peak Signal to Noise Ratio(PSNR), Reference Image, Singular Value Decomposition (SVD).

I. INTRODUCTION

THE accessibility to vast amounts of data with easy storage, processing and transmission with the increasing progress in information technologies and the availability to the Internet led to the unlimited sharing along the web. The ease of accessibility brought with it the disadvantage of unauthorized access and illegal means to tamper the data or misuse it in anyway possible. Thereby, comes the urgent need of measures to prevent this illegal grabbing. Various approaches such as watermarking, copy detection, digital signatures etc. are already there to put a check on them and continuous research in going on to develop more enhanced and robust methodologies. The approach of watermarking embeds secret information into the cover works such as logos, portraits or trademarks whose rightful ownership is to be proved, by extraction possible only by the real owners who possess the keys.

The watermarking schemes can be broadly classified into two categories: the spatial domain [1, 3, 5] and the frequency domain [2, 4, 6, 7, 8] techniques. The spatial domain watermarking schemes modify the digital data (pixels) directly to hide the watermark bits and possess the advantage of low computational complexity. However, the degree of robustness is usually low against the various types of signal

processing attacks. The frequency domain schemes doesn't alter the pixel values directly but rather modify the transform coefficients to hide the watermark bits. Various transform techniques like the Fast Fourier Transformation, Discrete Cosine Transformation, Discrete Wavelet Transformation etc. are available and their selection depends upon the application to be protected. The properties of these transforms are exploited to maintain the imperceptibility and robustness of the hidden watermarks. Thereby, inverse transformation of the modified coefficients are taken to generate the watermarked images. The robustness is usually high against the various types of signal processing attacks in the frequency domain but the computational cost is higher.

II. RELATED WORK

A simple watermarking scheme based on the discrete cosine transform (DCT) was proposed in [14]. It divided the input image into blocks and then applied DCT on each block independently. The low-frequency coefficients of the DCT block were selected for embedding the secret information using quotient-embedding algorithm. A robust watermarking scheme using the just noticeable distortion (JND) and DCT has been proposed in [15]. The JND value of the host image was used as embedding strength and the DC coefficients for embedding the watermark. The reliable identification of the watermark without requiring the original unwatermark image was addressed in [16] using the Maximum Posteriori probability criterion) for watermark detecting inserted into the DCT domain. Techniques analogous to spread spectrum communications for inserting watermark into the spectral components of the data was proposed by Ingemar et al. [17]. A sequence of real numbers was used as watermark, each number chosen independently from the normal (Gaussian) distribution. An adaptive digital watermarking scheme based on HVS was proposed in [18]. A mask function based on the Human visual system characteristics and extreme value of the energy function under some restrictions were used for embedding in the discrete cosine transformation domain.

The organization of the paper is as follows: the key concepts of the Discrete Cosine Transform and Singular Value Decomposition are discussed in brief in section 3. Section 4 describes the proposed methodology and experimental results with analysis are described in section 5. Conclusions along with the scope of future works are drawn in section 6.

III. BRIEF OVERVIEW OF THE CONCEPTS USED

A. Discrete Cosine Transform

Discrete cosine transformation is a widely used transformation in the field of image processing. DCT and

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IDCT transformations bridge the gap between the spatial domain and the frequency domain. The mathematical equations for the DCT and IDCT transformations are as follows:

$$F(m,n) = \frac{2}{\sqrt{MN}} C(m)C(n) \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) \times \cos \frac{(2x+1)}{2M} \pi m \cos \frac{(2y+1)}{2N} \pi n \quad (1)$$

$$F(x,y) = \frac{2}{\sqrt{MN}} \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} F(m,n) C(m)C(n) \times \cos \frac{(2x+1)}{2M} \pi m \cos \frac{(2y+1)}{2N} \pi n \quad (2)$$

Where $C(m), C(n) = \frac{1}{\sqrt{2}}$, when $m, n=0$, otherwise $C(m), C(n)=1$. $F(m,n)$ and $F(x,y)$ represent the pixel value in the DCT domain and the spatial domain respectively. $M \times N$ represent size of the block or the image.

The top left corner coefficient of the frequency domain matrix represent the DC value of the image, and the remaining coefficients represent the AC values. The magnitude of the energy possessed by each DCT coefficient is represented by the absolute value of the magnitude.

B. Singular Value Decomposition

The singular value decomposition (SVD) technique has been successfully used in a variety of applications, such as data compression, pattern analysis and signal processing [12, 13]. The image quality does not get deteriorate much by slightly changing the SVs of the SVD transform applied to the cover image. Also, the SV values are robust to the common image processing attacks and do not change much after their application to the image. From the linear algebra viewpoint, the SVD decomposition of any discrete image matrix A of size $m \times n$ can be represented as:

$$A = USV^T \quad (3)$$

Where U and V are orthogonal matrices ($U^T U = I, V^T V = I$) of size $m \times m$ and $n \times n$ respectively.

The horizontal and vertical details in an image are given by the columns of U and V matrices called as left and right singular vectors respectively. The diagonal matrix S with size $m \times n$, has nonzero elements called singular values of the matrix. They represent the luminance values of the image layers and as arranged in decreasing order from the first SV to the last one.

IV. THE PROPOSED METHODOLOGY

The proposed watermarking scheme consists mainly of two phases, watermark embedding and watermark extraction.

A. Watermark Embedding

The detail block diagram representation of the proposed embedding scheme is shown in Fig. 1

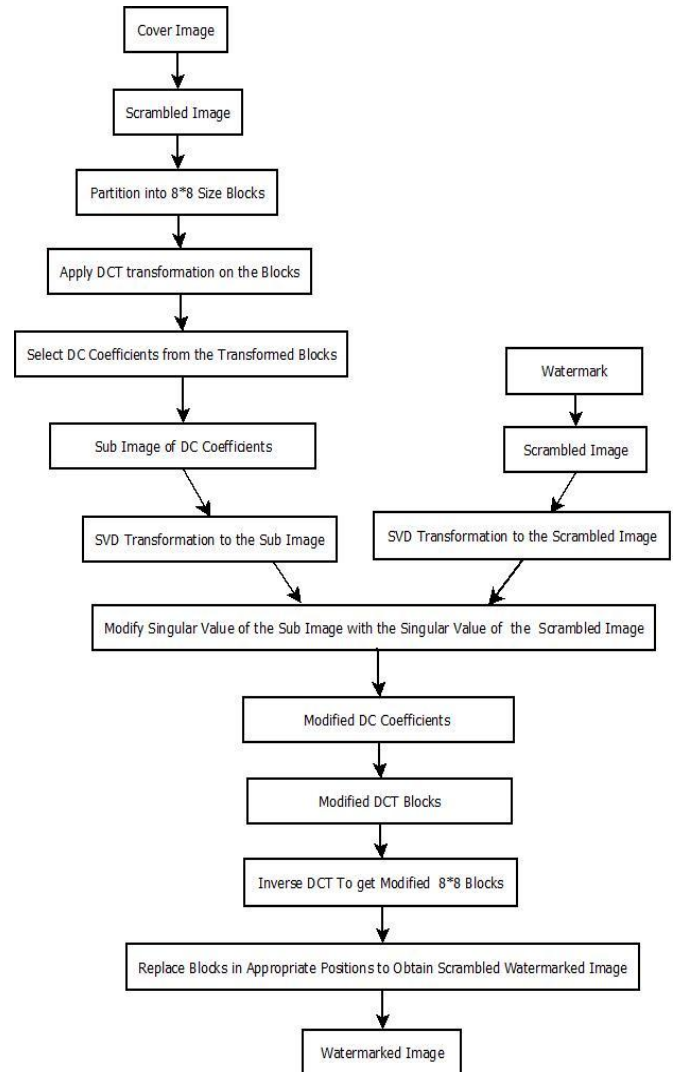


Fig. 1 Watermark Embedding

Step 1: Scan the Cover Image (C) in zig zag order to get a scrambled image (C_{scm}).

Step 2: Partition the scrambled image into 8 X 8 pixels block and perform discrete cosine transformation on it.

Step 3: Extract the DC coefficients from the sampled image to form a sub image of the DC coefficients of the cover image (C_{DC}).

Step 4: Apply SVD to the DC coefficient sub image (C_{DC}).

$$C_{DC} = U_{DC} S_{DC} V_{DC}^T \quad (4)$$

Step 5: Scramble the watermark (W) by scanning in the zig zag order (W_{scm}).

Step 6: Apply SVD to the scrambled watermark (W_{scm}).

$$W_{scm} = U_{scm} S_{scm} V_{scm}^T \quad (5)$$

Step 7: Obtain and modify the singular values of the DC coefficients of the sub image with the singular values of the scrambled watermark.

$$S_{DC}^{new} = S_{DC} + \delta S_{scm} \quad (6)$$

Where δ is a constant determining the embedding strength of the methodology.

Step 8: Inverse SVD to obtain the blocks of the modified DC coefficients and merge the blocks using the inverse discrete cosine transform to form the scrambled watermarked image.

Step 9: Obtain the watermarked image by descrambling in the reverse zig zag order.

B. Watermark Extraction

The detailed step by step procedure for the extraction phase is depicted in Fig. 2 and described in detail as follows:

Step 1: Obtain the Scrambled Watermarked Image C_{DC}^W by scanning in the zig zag order.

Step 2: Partition the scrambled watermarked image into 8 X 8 pixels block and perform discrete cosine transformation on it.

Step 3: Extract the DC coefficients from the sampled watermarked image to form a sub image of the DC coefficient.

Step 4: Apply SVD transformation to the sub image and obtain its singular values.

$$C_{DC}^W = U_{DC}^W S_{DC}^W (V_{DC}^W)^T \quad (7)$$

Step 5: Extract the singular values of the scrambled watermark.

$$S_{scm}^{ext} = (S_{DC}^W - S_{DC}) \div \delta \quad (8)$$

Where δ is a constant determining the strength of the methodology used at the time of embedding.

Step 6: Inverse SVD transform to obtain the scrambled watermark.

$$W^{ext} = U_{scm} S_{scm}^{ext} V_{scm}^T \quad (9)$$

Step 7: Inverse zig zag scan to obtain the watermark.

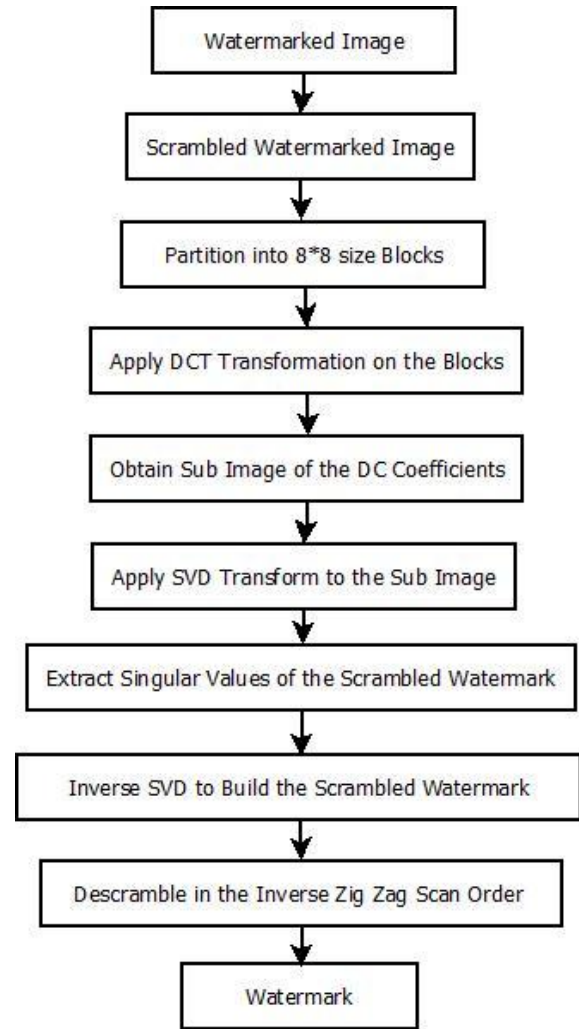
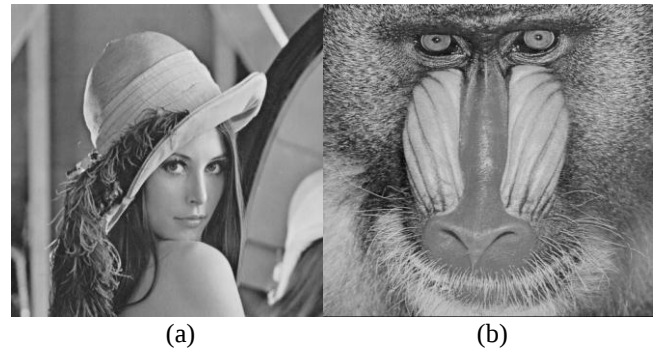


Fig. 2 Watermark Extraction

V. EXPERIMENTAL RESULTS AND ANALYSIS

The performance of the proposed methodology has been authenticated by simulating on a wide set of cover images and watermarks using MATLAB10. The cover images are gray scale images of size 512X512 and watermarks used are gray scale watermarks of size 64X64 as shown in Fig. 3 and Fig. 4.



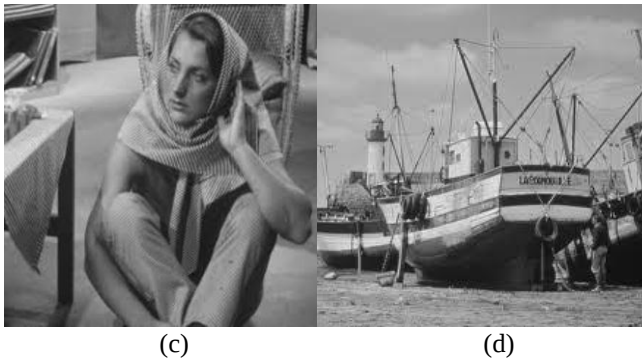


Fig. 3 (a), (b), (c),(d) cover images used

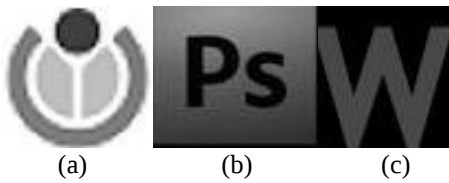


Fig. 4 (a), (b), (c) are watermarks used

A large number of experiments has been done with the above mentioned dataset of cover images and gray scale watermarks to test the efficacy of the proposed methodology. The imperceptibility of the watermarked image from the original cover image is measured with the Peak-Signal-to-Noise-Ratio (PSNR) metric. Its high achievable value in the experiments performed signifies the good indistinguishability of the watermarked image from the cover image. The strength of the algorithm varies with the constant value delta and its variation with the PSNR value is shown in Fig. 5.

To measure the robustness of the proposed methodology, a number of common image processing attacks has been applied on the watermarked image. To measure the

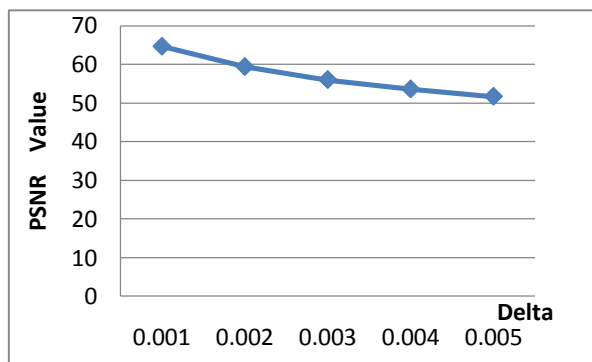


Fig. 5 Variation of PSNR with Delta Value

Similarity of the extracted and the original watermark quantitatively, another metric known as Normalized Cross Correlation (NCC) has been used. It is defined as follows:

$$NCC = [W_{ij} \times W'_{ij}] / [W_{ij} \times W_{ij}] \quad (10)$$

where W_{ij} and W'_{ij} are the pixel values at the $(i,j)^{th}$ position in the original and extracted watermark. Its value range from 0 to 1. The high values achieved by the NCC metric against the various attacks indicates its good robustness, tabulated in table 1 and comparative results in table 2.

TABLE I
ATTACKS APPLIED ON WATERMARKED IMAGE

Attacks Applied	NCC Value	PSNR Value
No Attack	1	64.64
Histogram Equalization	0.34	63.94
Wiener Filter(9 X 9)	0.98	64.17
Salt & Pepper Noise (variance=0.01)	0.98	24.14
Rotation (90 degrees)	1	36.67
Median Filter (9 X 9)	0.97	64.66
SpeckleNoise (variance=0.01)	0.99	64.58
Resize(512 to 128 to 512)	0.98	64.40
Average Filter(9 X 9)	0.96	64.66
JPEG (QF=50)	0.93	61.93
Gaussian Noise (variance=0.01)	1	62.92
Gaussian Filter (9 X 9)	0.98	62.92

TABLE II
COMPARATIVE NCC VALUES WITH PREVIOUS METHODOLOGY

Attacks Applied	Proposed Scheme	Previous Scheme[20]
No Attack	1	0.99
Rotation (90 degrees)	1	0.95
Median Filte(9 X 9)	0.97	0.68
Resize (512 to 128 to 512)	0.98	0.80
Histogram Equalization	0.34	0.99
Average Filter(9 X 9)	0.96	0.42
JPEG (QF=50)	0.93	0.92
Gaussian Noise(variance=0.01)	1	0.72
Salt & Pepper Noise(variance=0.01)	0.98	0.99

VI. CONCLUSION AND FUTURE SCOPE

A robust watermarking scheme integrating the key concepts of the singular values and the discrete cosine transform has been proposed in the present paper. The ownership verification can be done efficiently as the watermark is robust against the various attacks and is visually recognizable after the extraction. The security level is further enhanced by scrambling in the specific zig-zag order and the embedding strength used at the time of embedding, as only the rightful owner can extract the watermark knowing the actual parameters. The future study can be focused to make the scheme applicable to the video watermarking too, and further enhancing its robustness against more variety of attacks.

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