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International Journal For Research in  
Applied Science and Engineering Technology



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# **INTERNATIONAL JOURNAL FOR RESEARCH**

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

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**Volume: 7      Issue: II      Month of publication: February**

**DOI: <http://doi.org/10.22214/ijraset.2019.2029>**

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# Digital Image Watermarking using DCT and SVD

Prasham Bhargava<sup>1</sup>

<sup>1</sup>Department of Electronics and Telecommunication, Vishwakarma Institute of Technology

**Abstract:** Watermarking plays a pivotal role in today's age of multimedia to combat with piracy related issues. Being a technology that provides the capacity to hide information, digital watermarking attracted more attention in copyright protection. Embedding data into a multimedia element such as an image, audio or video file for copyright or authentication purpose is known as Watermarking. In this paper, a watermarking algorithm for digital images using Singular Value Decomposition (SVD) and Discrete Cosine Transform (DCT) is proposed. The DCT is preferred for image processing for lossy compression because it has a strong "energy compaction". On calculating SVD of the image, the singular values obtained contains properties which on altering do not affect the image visually. The host image is divided into blocks processed upon and then combined again to finally get the watermarked image. Using the inverse DCT the watermark can be extracted back from the image

**Keywords:** SVD; DCT; Blind watermarking; PSNR; MSE

## I. INTRODUCTION

In today's age of multimedia where technology has taken huge strides, it has become extremely easy to digitally transmit multimedia files such as audio clips, images, and videos. But at the same time, issues such as that of illegal duplication or piracy have become very rampant. There is umpteen number of cases where duplicate copies of a file are created illegally, without the knowledge of the original user. Here watermarking can help to combat such copyright issues. Watermarking plays an instrumental role in asserting of owners' right over his intellectual property. Watermarking involves the introduction of an element into the original file to uniquely identify its owner. Watermarking techniques can be categorized according to four different ways depending upon their working domains, host media, visibility of watermark and applications. The watermark can be classified into two primary kinds, which are the visible and invisible watermarks. In visible watermarking, the watermarking element is easily identifiable and hence can be easily maligned with. On the other hand, in the case of an invisible watermark, the embedded watermark is not visible and hence difficult to manipulate with. The watermarking systems are of two types- blind and non-blind. Blind watermarking systems do not require original data at the detector side while non-blind systems require original data at the receiver.

This paper is organized as follows. Section II briefs about literature review for watermarking techniques. Section III, IV and V explains watermark embedding and extraction process. Experimental results are discussed in Section VI. Section VII concludes the paper.

## II. LITERATURE SURVEY

The numbers of watermarking schemes have been proposed in the literature, each one of which employs a different methodology for embedding the watermark into the digital image.

In consonance with working domains, these techniques can be distinguished as spatial domain and frequency domain. The spatial domain watermarking techniques embed the watermark directly into the host image.

[1] Wu-He Jing presented an algorithm on digital watermarking using discrete cosine transform (DCT) in MATLAB environment [2]. Feng Liu and Ke presented an algorithm by employing singular value decomposition (SVD) and discrete cosine transform (DCT) for watermarking. It also discussed how the watermark satisfied the need for its transparency and robustness to common signal processing techniques including JPEG compressing noise, low pass filter and geometric cropping [3]. Samiksha Soni and Manish Sharma developed an algorithm using SVD and DCT [4]. A. Rajani and Ramashri implemented watermarking using DCT, SVD, and edge detection technique. Firstly, DCT is applied to the image block-wise followed by the SVD. The edge detection technique is meant for improving the invisibility of the watermark [5]. Sveldor and Dexter applied DCT to the image. After applying DCT to the image, the coefficients obtained were mapped in a zig-zag fashion into the four quadrants. The four quadrants represent the frequency bands from low to high. The advantage of each frequency band was also discussed [6]. C. T. Hsu and J. L. Wu proposed an image authentication technique by embedding digital "watermarks" into images. In this approach, the watermark is embedded with visually recognizable patterns into the images by selectively modifying the middle-frequency parts of the image [7]. M. A. Suhail and M. S. Obaidat proposed a watermarking algorithm based on discrete cosine transform (DCT) and image segmentation.

### III. PROPOSED METHOD

In this paper, an algorithm based on Singular Value Decomposition (SVD) and Discrete Cosine Transform (DCT) is presented. Figure 1 shows the algorithm for watermarking.

- 1) *Discrete Cosine Transform*: A transformation function which transforms the representation of data from space domain to frequency domain. One dimensional DCT is used in audio compression method. The only dimension of interest is time; two-dimensional DCT is used in image compression where the vertical and horizontal dimensions are considered
- 2) *Singular Value Decomposition*: In linear algebra, the singular value decomposition (SVD) is an important factorization of a rectangular real or complex matrix, with several applications in signal processing and statistics. The spectral theorem says that normal matrices can be unitarily diagonalized using a basis of Eigen vectors. Suppose  $M$  is an  $m$ -by- $n$  matrix. Then there exists a factorization for  $M$  of the form  $M = U \Sigma V^T$  where,  $U$  is an  $m$  by  $m$  unitary matrix, the matrix  $\Sigma$  is  $m$ -by- $n$  with nonnegative numbers on the diagonal and zeros on the off diagonal, and  $V^T$  denotes the conjugate transpose of  $V$ , an  $n$ -by- $n$  unitary matrix. Such a factorization is called a singular-value decomposition of  $M$ .
  - a) The matrix  $V$  thus contains a set of orthonormal 'input' vectors directions for the matrix  $M$ .
  - b) The matrix  $U$  consists of orthonormal 'output' basis vector directions for the matrix  $M$ .
  - c) The matrix  $\Sigma$  contains the singular values, which can be thought of as scalar 'gain controls'.

### IV. WATERMARK EMBEDDING

The digital watermark embedding process is divided into 5 steps and is briefly discussed below

- 1) *Step 1*: The original image (512×512) is first divided into square blocks of size  $4 \times 4$  pixels, then the DCT is applied in each block. Then The DC value  $F_{m,n}(1,1)$  ( $1 \leq m \leq 128, 1 \leq n \leq 128$ ) of each block  $F_{m,n}$  ( $1 \leq m \leq 128, 1 \leq n \leq 128$ ) is collected together to get a new matrix  $A$  ( $128 \times 128$ ).
- 2) *Step 2*: The new matrix  $A$  is divided into square blocks of size  $4 \times 4$  pixels, then perform SVD on each matrix to get matrices  $U$ ,  $S$ , and  $V$  for each block.
- 3) *Step 3*: Change  $S_{m,n}(1,1)$  ( $1 \leq m \leq 32, 1 \leq n \leq 32$ ) of each block  $S_{m,n}(1,1)$  ( $1 \leq m \leq 32, 1 \leq n \leq 32$ ) according to the methods given below:
  - a) Get  $Z_{m,n} = S_{m,n}(1,1) \bmod Q$  ( $1 \leq m \leq 32, 1 \leq n \leq 32$ ) where  $Q$  is the quantizing value.
  - b) When the value of the watermark  $W(m,n)$  ( $1 \leq m \leq 32, 1 \leq n \leq 32$ ) is zero:
 

If  $Z_{m,n} \in [0, 3Q/4)$ ,  $S'_{m,n} = S_{m,n}(1,1) + Q/4 - Z_{m,n}$  else

If  $Z_{m,n} \in [3Q/4, Q)$ ,  $S'_{m,n} = S_{m,n}(1,1) + 5Q/4 - Z_{m,n}$
  - c) When the value of the watermark  $W(m,n)$  ( $1 \leq m \leq 32, 1 \leq n \leq 32$ ) is non-zero:
 

If  $Z_{m,n} \in [0, Q/4)$ ,  $S'_{m,n} = S_{m,n}(1,1) - Q/4 - Z_{m,n}$  else

If  $Z_{m,n} \in [Q/4, Q)$ ,  $S'_{m,n} = S_{m,n}(1,1) + 3Q/4 - Z_{m,n}$
- 4) *Step 4*: Apply the new  $S'_{m,n}(1,1)$  to get a new  $S'_{m,n}$  then apply  $A^*_{m,n} = U S'_{m,n} V$  to get a new matrix  $A^*_{m,n}$  ( $128 \times 128$ )
- 5) *Step 5*: Make  $F_{m,n}(1,1) = A^*_{m,n}(1,1)$ , and perform  $4 \times 4$  inverse block DCT and recombine modified coefficients to obtain the watermarked image  $I^*$  ( $512 \times 512$ )

### V. DIGITAL WATERMARK EXTRACTION

The digital watermark extraction process is divided into 3 steps and is briefly described below:

- 1) *Step 1*: Apply  $4 \times 4$  block DCT to watermarked images  $I^*$  ( $512 \times 512$ ) and then the DC value of each block are collected together to get a new matrix  $A^*$  ( $128 \times 128$ ).
- 2) *Step 2*: The new matrix  $A^*$  is divided into square blocks of size  $4 \times 4$  pixels, then Perform SVD on each matrix to get matrices  $U$ ,  $S^*$  and  $V$  for each block.
- 3) *Step 3*: Get  $S_{m,n}(1,1)$  ( $1 \leq m \leq 32, 1 \leq n \leq 32$ ) of each block, then get the value of watermark  $W^*(m,n)$  ( $1 \leq m \leq 32, 1 \leq n \leq 32$ ) according to the method below:

Get,

$$Z^*_{m,n} = S^*_{m,n}(1,1) \bmod Q \quad (1 \leq m \leq 32, 1 \leq n \leq 32)$$

If  $Z^*_{m,n} \in [0, Q/2)$ ,  $W^*_{m,n} = 0$

Else if  $Z^*_{m,n} \in [Q/2, Q)$ ,  $W^*_{m,n} = 1$

- 4) *Step 4:* Enter the exact value of Q to extract the watermark. Unless you enter the exact value, watermark can't be extracted and viewed.

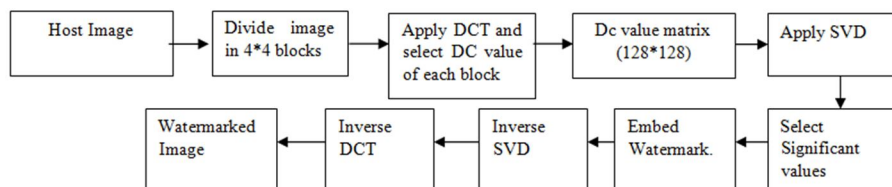


Fig. 1. Block Diagram

## VI. EXPERIMENTAL RESULTS

In this study, the cover image size is  $512 \times 512$  and DCT block size is  $4 \times 4$ , SVD block size is  $4 \times 4$ . Then, the size of the approximate image generated with SVD values is  $32 \times 32$  and so is the size of the watermark. MATLAB and Image Processing Toolbox are used for the experiments and attacks. The performance investigation of our algorithm by is done by computing the PSNR (Peak Signal-to-Noise ratio) between the original image and watermarked image. The algorithm is tested on a variety of images, but for the sake of space, here the results obtained using the  $512 \times 512$  grayscale image Lena and  $32 \times 32$  binary watermarks are presented.

Table 1. Images and their results

| Sr. No. | Host Image | Average MSE of watermarked image | Average PSNR of watermarked image |
|---------|------------|----------------------------------|-----------------------------------|
| 1       | Lena       | 0.00031                          | 92.816                            |
| 2       | Baby       | 0.0317                           | 63.53                             |
| 3       | Tank       | 0.0146                           | 66.48                             |
| 4       | Baboon     | 0.0017                           | 75.92                             |
| 5       | Pelican    | 0.0011                           | 77.85                             |
| 6       | Valley     | 0.016                            | 87.84                             |



Fig. 2. Host image



Fig. 3. Watermark



Fig. 4. Watermarked image



Fig. 5. Extracted Watermark





Fig. 6. Host image



Fig. 7. Watermark



Fig. 8. Watermarked image



Fig. 9. Extracted Watermark

## VII. CONCLUSION

The algorithm for digital watermarking using the combination of SVD and DCT was successfully implemented. As can be seen from the results, there is hardly any visual difference between the original image and the watermarked image. The two look identical. Therefore, the watermarked image can serve the purpose of claiming the ownership rights. Also, the PSNR values for different cases are calculated and tabulated. The PSNR value is a measure of how the image gets affected with respect to the original image, once the watermark has been inserted. It is a measure of similarity between two images. Also, as can be observed from the extracted watermark that is a bit distorted. This is due to the introduction of noise in it. The variation in the numerical values obtained while applying the watermark embedding and extraction algorithm is responsible for it.

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45.98



IMPACT FACTOR:  
7.129



IMPACT FACTOR:  
7.429



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