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Digital Color Image Watermarking In RGB Planes Using DWT-DCT-SVD Coefficients

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***Abstract*—Watermarking is mainly used for copyright protection for multimedia data. This paper presents Discrete Wavelet Transform, Discrete Cosine Transform and linear algebra called Singular Value Decomposition (DWT-DCT-SVD) for digital image watermarking. In our technique the color image is divided into three color components red, green and blue .Select blue component apply two level DWT. It divides the image into four multiresolution sub bands and we select the sub band with median energy, apply DCT and then apply SVD for it and embed the watermark. The experiments are carried out and our proposed algorithm provides robustness.**

***Keywords*—Discrete Wavelet Transform, Discrete Cosine Transform, Singular Value Decomposition**

I. Introduction

Now a day's Majority of the digital images are exchanged over the internet. It is simple to reproduce perfectly at any medium. We can insert the watermark in any medium like audio, video and image to identify the ownership. The watermark embedding procedure should meet two conditions: The watermark must be imperceptible and robustness.

Data hiding techniques are classified into 2 types: Spatial Domain [1] and Frequency Domain [2, 3, 4]. Here we are using semi-blind scheme [5] and the frequency domain techniques like Discrete Wavelet Transform and Discrete Cosine Transform [8] and Singular Value Decomposition [6] for embedding the watermark. Here the Original Image is divided into three color components red, green and blue and selects the blue channel for embedding the watermark [7].For robustness the original image is transmitted into watermarked image after transforming into other spaces like DWT, DCT and SVD. In the color image select the blue channel and then apply different transforms.

Discrete Wavelet Transform

Discrete Wavelet Transform is any wavelet transform for which the wavelets are discretely sampled. The main advantage of Wavelet Transform over Fourier Transform is it capture both frequency and location information. Here the image is divided into four multi resolution sub bands LL, LH, HL and HH. Calculate energy and find the median and apply next level.

The DWT is performed for all image rows and then all image columns.

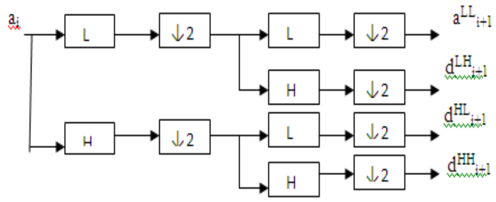


Fig 1.Wavelet decomposition for two dimensional images

Discrete Cosine Transform A discrete cosine transform is a finite sequence of data points in terms of a sum of cosine functions oscillating at different frequencies.

$$F(u,v) = \left(\frac{2}{N}\right)^{\frac{1}{2}} \left(\frac{2}{M}\right)^{\frac{1}{2}} \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} \Lambda(i).\Lambda(j).\cos\left[\frac{\pi.u}{2.N}(2i+1)\right] \cos\left[\frac{\pi.v}{2.M}(2j+1)\right].f(i,j)$$

f (i, j) is the intensity of the pixel in row I and column j.

F (U, V) is the DCT coefficient

Singular Value Decomposition

The Singular Value Decomposition is a factorization of a real or complex matrix in linear algebra. The basic idea behind Singular Value Decomposition is, taking a high dimensional and highly variable set of data points and reducing it to a lower dimensional space that exposes the substructure of the original data more clearly and orders it from the most variation to the least. The Singular Value Decomposition of the mxn matrix T is of the form

$T=USV^T$.

Where U is a m x m real or complex unitary matrix

S is a rectangular m x n matrix with non negative real numbers on the diagonal.

V^T is a n x n real or complex unitary matrix

Singular Values of the image gives very good stability. When a small value is added, it does not result too much variation. An important property of SVD based watermarking is that the largest of the modified singular values change very little for most types of attacks.

II. Proposed Method

Our method consists of the following steps:

1. Decompose into 3 color components red, green and blue.

2. Apply 2_level DWT and then apply DCT.

3. Apply SVD technique on the selected sub band.

2.1. Watermark Embedding algorithm:-

1. Consider I as the original color image and W is the gray level watermark image.

2. Decompose the original image into red, green and blue components.

3. Select blue component and apply DWT to it. The blue component is divided into 4 multi resolution sub bands O1, H1, V1 and D1.

4. Calculate energy for H1, V1 and D1 by using the following formula. Select the sub band which has median energy value.

$$E_{subband} = \frac{\sum_{x,y} d_{x,y}^{subband}}{n}$$

Where n is the number of pixels in the sub band.

5. Apply 2^{nd} level DWT for median energy sub band, then we get O2, H2, V2 and D2 sub bands.

Again calculate energy for H2, V2 and D2 and select the median energy sub band.

6. Apply Discrete Cosine Transform and then Singular Value Decomposition technique for the sub band with median energy, and then we get three matrices U, S and V.

7. Apply the watermark technique for the watermark image W and then we get three matrices UW, SW and VW.

8. Combine the watermark W with the S using appropriate scaling factor α.

$S1 = S + \alpha * SW$

9. Apply inverse Singular Value Decomposition technique $U*S1*V^T$.

10. Apply inverse DCT and two level inverse DWT.

11. Combine red, green and modified blue channel then we get the watermarked image WM.

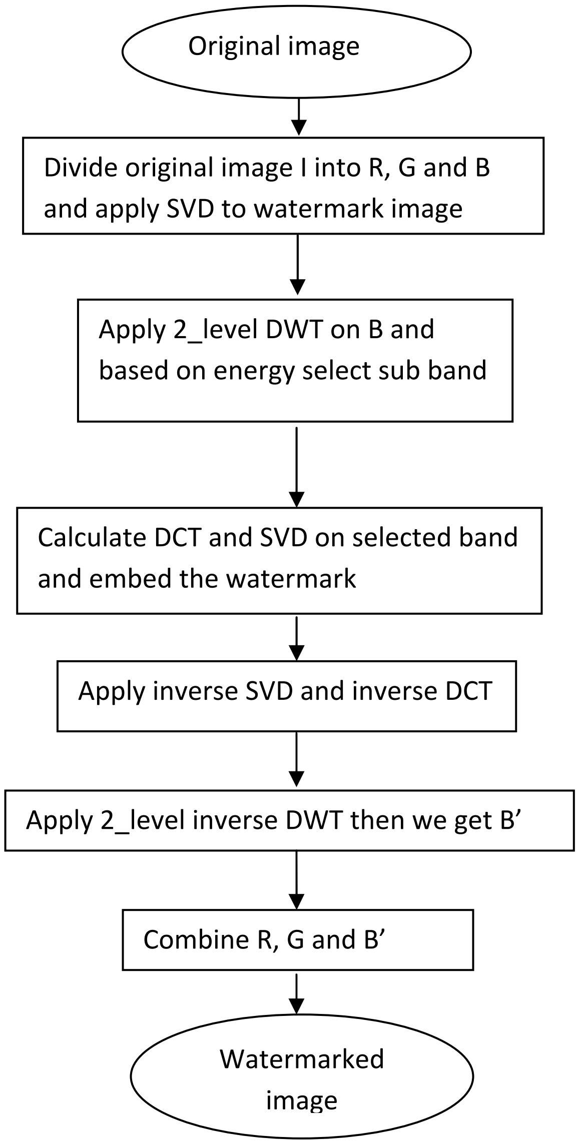


Fig 2. Watermark embedding procedure

2.2. Watermark Extraction Procedure:-

1. Consider the watermarked image WM and divided into red, green and blue components.

2. Select the blue component and apply the DWT and select the sub band based on the median energy.

3. Apply second level DWT for the selected sub band and calculate energy and select the sub band.

4. Apply DCT for the selected sub band and apply SVD technique, then we get U1, S1 and V1.

5. We can extract DW by using the following formula

$$DW= (S1-S)/\alpha$$

6. Apply inverse Singular Value Decomposition $UW*DW*VW^T$, then we get the extracted watermark image.

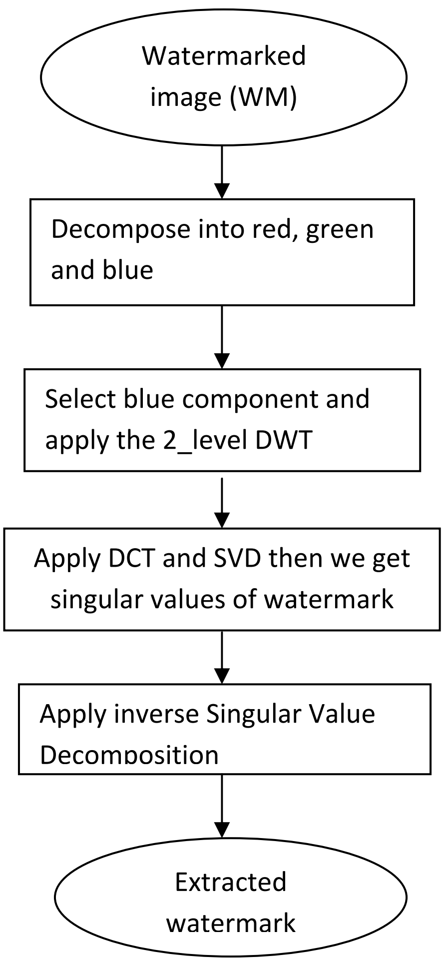


Fig 3. Extraction procedure

III. Performance Analysis

The performance of the watermarked image is measured by using Mean Square Error and Peak Signal to Noise Ratio between original image and watermarked image. The performance of the extracted image is calculated by using Standard Deviation (SD) and Normalized Correlation (ND) between watermark image and extracted watermark image.

Mean Square Error:

MSE is the mean of the square of the pixel values between the corresponding pixels of original and watermark images.

$$MSE = \frac{\sum_{r,g,b}\sum_{i=1}^{m}\sum_{j=1}^{n}(O[i,j]-WM[i,j])^2}{3*m*n}$$

here O and WM are the original image and watermarked image. m, n are the image row and column sizes.

Peak Signal to Noise Ratio:

We can measure the quality of the watermarked image by using the PSNR.

PSNR for the image of size m x n is given by

$$PSNR = 10 * \log\left[\frac{R^2}{MSE}\right]$$

Where R is the maximum fluctuations in the input image.

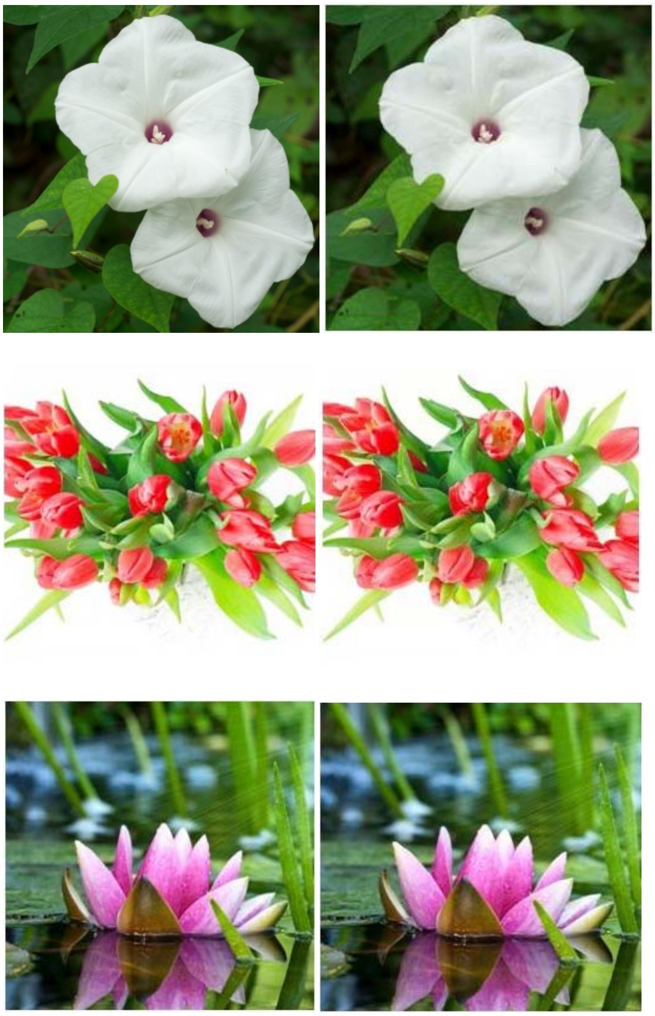
Normalized Correlation:

$$NC = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(W[i,j]EWM[i,j])}{\sqrt{\sum_{i=1}^{m}\sum_{j=1}^{n}(W[i,j])^2}\ \sqrt{\sum_{i=1}^{m}\sum_{j=1}^{n}(EWM[i,j])^2}}$$

The normalized correlation peak value is 1.If NC=1 two images are equal, NC=0 if two images are not equal.

IV. Results

We use three color flower images of size 256 X 256 and the watermark is 64 X 64 gray image. The results are shown below:



Original Images Watermarked Images

Watermark image

Extracted Watermark

V. Analysis

We test the results of the proposed method SVD in between the Original Image and the Watermarked Image by using the Mean Square Error and Peak Signal to Noise Ratio. We also check the performance of SVD in between Watermark Image and Extracted Watermark Image.

TABLE 1
MSE AND PSNR BETWEEN COVER IMAGE AND WATERMARKED IMAGE

Image	MSE	PSNR
Flower1	18.3504	35.4944
Flower2	21.6300	34.7802
Flower3	20.2406	35.0686

TABLE 2
SD AND NC BETWEEN WATERMARK IMAGE AND EXTRACTED WATERMARK IMAGE

Image	NC
Flower1	0.9993
Flower2	0.9991
Flower3	0.9996

VI. Conclusion

Singular Value Decomposition is the Linear Algebra technique used for digital image watermarking. In the proposed method SVD is applied on watermark image and is embedding in the SVD of the Original image. SVD belongs to Spatial Domain Transform .Based on the results we can say that our proposed method is good for embedding because the original image and watermarked images are visually same. We are using DWT and DCT for getting the high frequency images has robustness in geometrical attack.

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