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Apply the fusion of Watermarking techniques on coloured image using layered approach

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Abstract- Watermarking technique is used to solve the issue related to security of data and copyright degradation. This issue has to be determined by keeping a steady prove on the imperceptibility and robustness or strength which incur to be its major goal. In order to achieve these objectives the usage of a mixed (hybrid) transformation is adopted in this paper, the main idea behind applying a hybrid transform is that the cover image is modified in its singular values rather than on the DWT sub-bands, therefore the watermark makes it vulnerable to vivid attacks and maintains its original state. Some simulation results are available to support the methods and relative study.

Index Terms- Authentication, copyright protection, robustness, Hybrid, Singular Value Decomposition (SVD), Discrete Wavelet Transform (DWT)

I. Introduction

The enhancing usage of digitization has given a great lead to the digital society; the digital mode of communication is building its grip tight on the broadcasting of images, text videos, and audio. But with the improvisation of the digital communication media its degradation has also got amenable, thus to deprecate the copyright defiance digital watermarking implies to its best [1], [2].

Digital watermark insertion is in the definite domain, i.e. either in the spatial domain or the transform domain. The diversity in these domains is that, in case of spatial domain the embedding of the watermark is a straightforward method. The spatial-domain components of the original image are embedded with the digital watermark; due to the straightforward acting behaviour the spatial domain has a low complexity and easy implementation as its plus points. But on the contrary, spatial domain method is not immune to image-processing operations and other attacks.

Whereas, the transform domain (frequency domain) carries the embedding of the watermark by modulating the magnitude of the coefficients of the image in the desired transform domain, for instance: DCT (discrete cosine transform), DWT (discrete wavelet transform), and SVD (singular value decomposition) [3]. The positives of a transform domain is its ability to yield maximum information after embedding the watermark and improved robustness against various attacks, but it has a flaw of increased computational cost in comparison to spatial-domain [4].

On taking into account the DWT, it has its spatial-frequency localization property which sectors the entire image into different frequency coefficients and the areas where the watermark can be embedded imperceptibly are easily accessible. SVD has a mathematical property where minute amendments in the singular values do not cause much havoc on the visual perception of the cover image, thereby improving the robustness and transparency [5].

II. Background Review

a. DWT

Discrete Wavelet Transform can be defined as any wavelet transform for which waves are discretely sampled. DWT in mathematical terms fit well to be a hierarchical tool for decomposing an image. The advantage of DWT over Fourier Transform is its ability of generating temporal resolution and that it captures both frequency and location information. The translations and dilations of the wavelet are caused by the mother wavelet.

DWT enumerates the high and the low frequency components by splitting the image into its respective frequency components. The high frequency components bequeath for the edge detection whereas the low frequency components are again bifurcated into high and low frequency components. The purpose of watermarking is served by the high frequency components as the human eye is sensitive on the edge variations [6].

The levels of DWT implementation can be on a multistage level transformation. For the first stage decomposition by DWT the image is divided into its LL, LH, HL, and HH plane. The LH, HL, and HH plane represent the finest scale wavelet coefficient whereas the LL plane represents the coarse-level coefficient. Therefore fro edge detection purposes the LL plane can undergo the desired number of DWT levels [7].

b. SVD

The Singular Value decomposition yields the purpose of reduction of complexity by dividing the non-negative image matrix into $U * S * V^T$, where U and V are the orthogonal matrices and S is the diagonal matrix of singular values of the original matrix arranged in decreasing order [8].

The usage of singular values volumes to the robustness of the image, i.e. when any perturbation is added on the image large variations in the singular values do not occur. Additively singular values represent intrinsic algebraic properties [9].

c. Proposed DWT-SVD Scheme

The proposed DWT-SVD scheme is formulated as given under steps:

1) Extract the red component of the given image with (:, :, 1)
2) One level 'Haar' Discrete Wavelet Transform to decompose cover image into 4 subbands.

[ca1, ch1, cv1, cd1]=dwt2 (*image*,'haar')

3) Apply Singular Value Decomposition to the vertical (cv1) and horizontal (ch1) coefficients.

[U1, S1, V1]=svd(ch1)
[U2, S2, V2]=svd(cv1)

4) Divide the watermark into two parts W1, W2.

W=W1+W2

5) Extract the red component of the watermark as well similar to for the image, with (:, :, 1).
6) Modify the particular singular values of vertical and horizontal plane in step 2. Along with the inputted scale factor (α).

$S1 + \alpha W1 = Uw * Sw * Vw^T$
$S2 + \alpha W2 = Uw * Sw * Vw^T$

7) Two sets of modified DWT coefficients are complete available by 4.

Mod_c_h = U1 *Sw *V1'
Mod_c_v = U2 *Sw *V2'

8) Apply the inverse Discrete Wavelet Transform, i.e. i-dwt on the two sets of modified coefficients in step 5 (cv1 and ch1) and non-modified coefficients in 1 (ca1 and cd1).

WI=idwt2 (ca1, Mod_c_h, Mod_c_v, cd1,'haar')

9) Replace the 1st component of the image that is processed with the original image's first component.
10) Extraction of the watermark:

For the Extraction of the watermark: (in the red component). Apply one level Haar DWT to the watermarked image obtained in step6.

[ca2, ch2, cv2, cd2] = dwt2 (WI,"haar')

11) Apply SVD to the horizontal and vertical coefficients, where U and V are of original image and S is of the watermarked image from step 2 and step 4 respectively.

[U1, Sw, V1] = svd (ch2)
[U2, Sw, V2] = svd (cv2)

12) Compute the replaced coefficients by placing the V and U of the original watermark along with the singular value S used in 8.

M_c_h = Uw *Sw *Vw'
M_c_v = Uw *Sw *Vw'

13) Extract half of the watermark by

$W1^* = (M\_c\_h – S1) / \alpha$
$W2^* = (M\_c\_h – S2) / \alpha$

14) Combine the results of step 4 to obtain the new original watermark.[10]

W* = W*1 +W*2

III. Experimental Results

Colour Image Consist of three layers Red, Green and Blue (RGB), we can easily retrieve each layer. Each layer consists of 0 to 255 pixel values and it behaves as Gray image. So first we divide the colour image into three layers and then the watermark image fuse into it. After fusing the image we can combine and construct the watermarked colour image (layer 1) and send to the receiver.

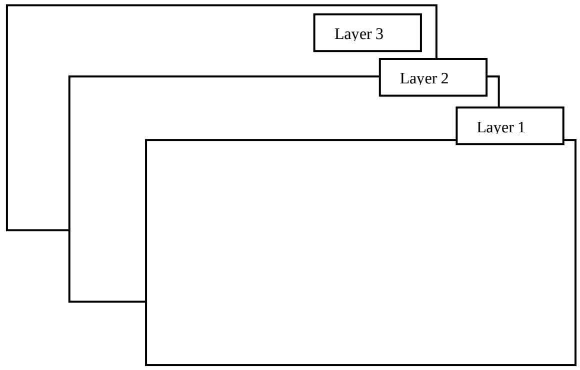

Figure 1 Colour image m x n x 3

Red Layer (m x n of first layer pixel Values from 0 to 255)
Green Layer (m x n of second layer pixel values from 0 to 255)
Blue Layer (m x n of third layer pixel values from 0 to 255)

As we know that every colour image consists of three layers and each layer having the combination of pixel values of the RGB colour components. The very first layer is belongs to red layer, the second layer is Green layer and the third layer is blue layer.

Experiments are conducted to demonstrate the proposed approach. The coloured image "chrysanthemum" of size 256 × 256 is used as the cover image and the colour image "sunset" of size 128 × 128 is used as the watermark image. These images are shown in Fig. 1(a) and 1(b) which are of the cover and watermark respectively. Fig. 1(c) illustrates the Grey cover image (of layer 1) and Fig. 1(d) is the Grey watermark image. Fig. 1(e) illustrates the Grey watermarked cover image and Fig. 1(f) is the Grey extracted watermark image.

The observation of the proposed approach yields the preserved high perpetual quality of the watermarked image.

As a parameter of quality, peak signal-to-noise ratio (PSNR) has been used. The PSNR illustrates the maximum fluctuation of pixels with the mean square error of the images and helps in easy analysis of the variations and degradations being caused on the image by comparing the peaking pixel values.

$PSNR = 10 \log_{10} (R^2 / MSE)$
$MSE = sum [(I1 (m, n) – I2 (m, n))^2] / m*n$

Where, R is the maximum fluctuation of pixels and m, n are the row and column matrix of the images.

(a) (b)

Fig. 2 (a) Cover Image (b) Watermark image

(c) (d)

Fig. 2 (c) Grey Cover Image (d) Grey Watermark Image

(e) (f)

Fig. 2 (e) watermarked Image (f) Extracted Watermark Image

In the experiment the values of the scale factor has been carried out from 0.01 to 4 with a random interval. The graph presented in the Figure 3 illustrates the PSNR of the extracted image, and of the watermarked image. It is clear from the presented graph that the robustness of the watermark is maintained at a perpetually high level.

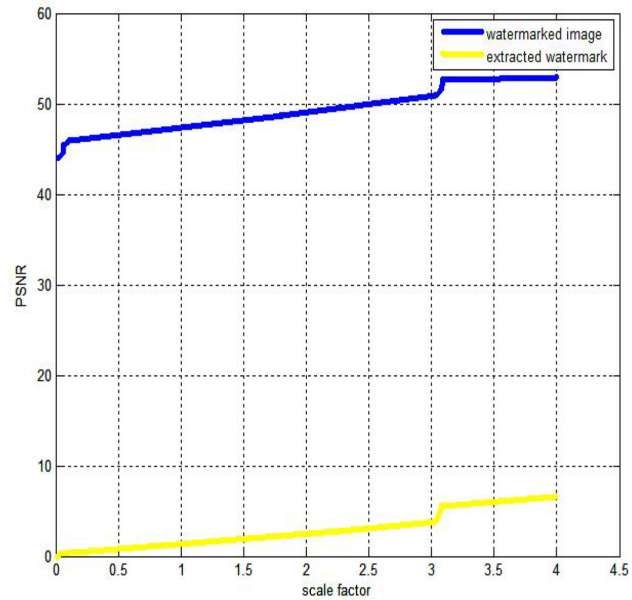

Figure 3- PSNR of the Watermarked Image and Extracted Watermark

The varying range of the PSNR of the images used in order to draw the comparison has been presented in the Table 1 below:

Scale Factor	0.05	0.1	0.2	0.5	1.5
Watermarked Image	50.002	44.064	38.222	30.936	18.123
Extracted Watermark	12.456	14.483	17.244	22.236	31.203

Table I. Comparative analysis of PSNR at different scale factor values for resultant images

On changing the value of the scale factor the PSNR fluctuates indicating the status of the robustness of the watermark in the image and after extraction. This experimental result is mainly applied on first layer; similarly we can apply the algorithms in rest of two layers. After applying the concept in all three layers we can combine and construct the watermarked image.

To contemplate the robustness of the presented approach the watermarked image is tested against various attacks. Attack can be applied on individual layers image as well as combine layer image. The PSNR values indicate the quality of watermark image and the watermarked images.

IV. Conclusion

In this paper a hybrid watermarking scheme using SVD and DWT has been introduced, where the watermark is embedded in the singular values of the red component of the cover image's DWT sub bands and then combined with the other two i.e. green and blue components to yield the watermarked image. The methods adopted fully exploit the features of the SVD and DWT transform. The intrinsic algebraic properties of the image represented by SVD and the spatial-frequency localization of DWT are well utilized. Experimental results are made available which depict the improved imperceptibility and robustness under attacks and preserve copyrights by using this technique. In this present approach for robustness we can apply various attacks on the images and check the correspondent PSNR values. Further work of integrating human visual system (HVS) characteristics into our approach is in progress for robustness and more secure application.

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