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An imperceptible Transform Domain Based Digital Image Watermarking Scheme with YUV color soace

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Abstract— **Digital image watermarking is the process for data hiding and provides extension of maximum security from unauthorized persons. This paper proposed an imperceptible transform domain based digital image watermarking scheme with YUV color space. Initially the RGB (Red, Green & Blue) cover image is converted into YUV model then performs Hadamard transform (HT) on Y (Luminance) component to obtain coefficient values of those images. The second step is perform embedding process in between Y coefficient values and watermark image with help of scaling factor (α) to obtain new Y components. Last step is to obtain watermarked image after applying the inverse Hadamard transform and also conversion of YUV to RGB. Finally to extract the watermark image without any distortions at receiver side after performing reverse embedding process. The experiment results provide better values than the existing ones using quality factors like Peak Signal to Noise Ratio (PSNR), Mean square error (MSE), Similarity measures (SSIM) and normalized cross correlation (NCC).**

Keywords— **Color image, Digital image watermarking, Hadamard Transform (HT), PSNR, MSE, SSIM and NCC.**

INTRODUCTION

In recent years, most of the researchers are doing their research in field of image watermarking. The process of image watermarking is embedding a secrete image into the cover image to get more efficient output i.e watermarked image. The watermarked image should be imperceptible & secure from any unauthorized persons. The scaling factor plays dominant role in image watermarking process. It shows the strength of the watermarking level [1-3].

Generally the image watermarking algorithms like time and spectral domain. In Spatial domain perform the data hiding and then reverse process by changing the pixel values of the cover image but in spectral domain perform watermarking operations on their coefficient values.

The spectral domain based approach provides a better security than the time domain. The spatial domain techniques are LSB, etc. and spectral domain techniques are DFT [4]

(Discrete Fourier transform), DCT [4-5] (Discrete Cosine Transform, etc).

The remainder of this paper is arranged as following manner. The preliminaries are discussed in section II. The proposed watermarking process (methodology), results and concluded parts are discussed in III, IV & V sections.

RELATED WORK

HT domain

The HT transform is not a sinusoidal transform. In the Hadamard transform the kernel values are either +1 or -1 [6-7].

The properties of HT are
(1) it is a real and orthogonal,
(2) Symmetric property,
(3) Sequency ordered etc.

The basic Hadamard transform matrix is constructed for $N = 2^n$ by using following procedure:

The basic Hadamard transform matrix of order 2 is given as

$$H_2 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \quad (1)$$

The Hadamard matrix of order 2N is

$$H_{2N} = \begin{bmatrix} H_N & H_N \\ H_N & -H_N \end{bmatrix} \tag{2}$$

For Example N=2 in equation 2, we can get

$$H_4 = \begin{bmatrix} H_2 & H_2 \\ H_2 & -H_2 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix} \tag{3}$$

Let us consider F is the input image and F' is the Hadamard transform image. The representation of 2D Hadamard transform of F is given by

$$\left[F'\right] = \frac{H \times F \times H}{N} \tag{4}$$

and its inverse is given by

$$\left[F\right] = \frac{H \times F' \times H}{N} \tag{5}$$

The Orthogonality is defined as:

$$HH^T = 1 \tag{6}$$

YUV color space

The RGB color space is useful for display point of view. The Red, Green and Blue components are adding together to reproduce various color models.

YUV is means Y (luminance) and chrominance (U and V) two used typically for color image processing. The YUV model is majorly used to reduce the bandwidth and provide the information without perceptual deviations [8].

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.14713 & 0.28886 & 0.436 \\ 0.615 & -0.51499 & -0.10001 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \tag{7}$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 & 0 & 1.13983 \\ 1 & -0.39465 & -0.58060 \\ 1 & 2.03211 & 0 \end{bmatrix} \begin{bmatrix} Y \\ U \\ V \end{bmatrix} \tag{8}$$

METHODOLOGY

The watermarking technology is important research field to provide the security to data (image, text, video, etc) from unauthorized persons (hackers). The profession of image watermarking to perform image embedding and extraction process with help of strengthens factor (α).

The watermark embedding algorithm is not visible and high secure. There are many types in embedding and extraction process of both time and spectral domains

The proposed process is shown in Figure. 1 (a) & (b). Here the proposed method is using Hadamard transform based secure & invisible digital image watermarking scheme.

This proposes of watermarking scheme which embeds watermark in the following ways:

Data hiding procedure

Step 1: Read cover image (in) and secrete (watermark) images (w) with sizes 256*256*3 and 256*256.

Step 2: Convert cover image into YUV model to obtain three different images like Luminance (Y), and two chrominance (U and V).

Step 3: Take Y image and apply Hadamard transform (eq 4) to get a coefficient values of image (y1).After that perform embedding operation in between y1 image and gray level watermark image (w) with a scaling factor α=0.0005 and also apply inverse Hadamard transform to obtain new coefficients of luminance image (y111).

$$\begin{aligned} & y1 = hadamard(Y); \\ & y11 = y1 + (0.0005 * w) \\ & y111 = invhadamard(y11) \end{aligned} \tag{9}$$

Step 4: Finally, combine unchanged values of U, V and y111 and then convert YUV to RGB to obtain watermarked image (WD).

$$\begin{aligned} & p = cat(3, y111, U, V) \\ & WD = YUV2RGB(p) \end{aligned} \tag{10}$$

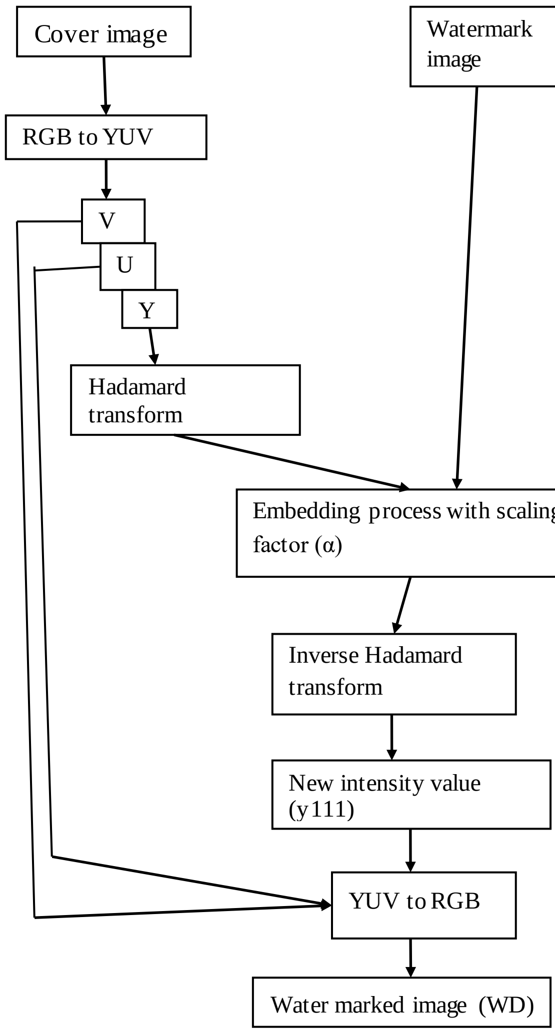

Fig 1 (a): Algorithm for data hiding process

Data extraction procedure

Step 1: Read the watermarked image.

Step 2: convert step 1 from RGB color space to YUV model.

Step 3: Now, apply Hadamard transform on Luminance image (Y) to obtain the transform coefficients (Y1).

Step 4: Now, extract the watermark image from subtraction between luminance coefficient image (Y1) of watermarked image & color cover image (y1) with scaling factor (α).

$$we = (Y1 - y1) / 0.0005 \tag{11}$$

This process is known as Image watermark extraction.
Step 5: Finally, the watermark image is obtained.

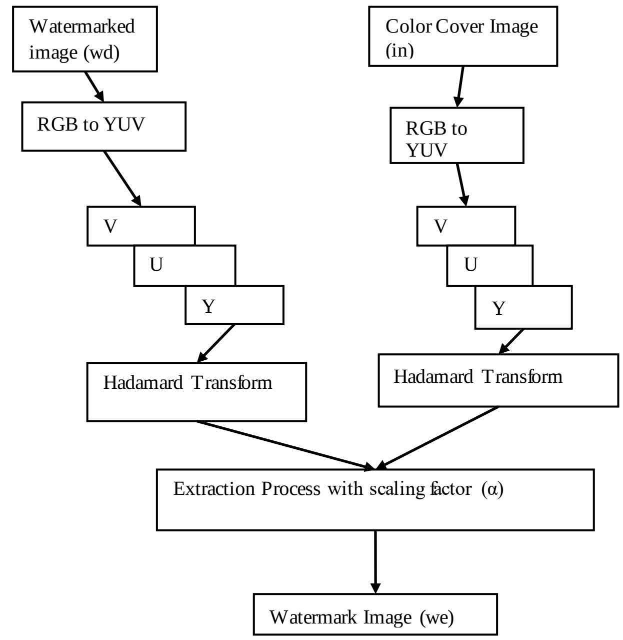

Fig 1 (b): Algorithm for reverse embedding process

EXPERIMENTAL RESULTS

The proposed algorithm was implemented in MATLAB 2018. The sizes of cover and watermark image are 256X256X3 and 256 X256. The experimental results of host watermark, hiding & reverse embedding images are displayed in Figure 2. The table 1 & 2 shows the comparison of existing and proposed methods with various quality metrics (PSNR, MSE, SSIM, RMSE and NCC).

PSNR

The *PSNR* is quality factors for image processing applications. The PSNR can be computed between cover image and embedded image. It is defined as follows:

$$PSNR(dB) = 10 * \log_{10}\left[\frac{(255)^2}{\frac{1}{X \times Y}\sum_{x=0}^{X-1}\sum_{y=0}^{Y-1}\left(in(x,y) - wd(x,y)\right)^2}\right] \tag{12}$$

The highest PSNR value means watermarked image is good quality [9].

Structural similarity index

This metric used to calculate similarity between two images like watermark (w) and extracted watermark image (we). Its values are between -1 to 1.

$$SSIM(w, we) = I(w, we)C(w, we)S(w, we) \tag{13}$$

Where

$$\begin{cases} I(w,we) = \dfrac{2\mu_w \mu_{we} + C_1}{\mu_w^2 + \mu_{we}^2 + C_1} \\ C(w,we) = \dfrac{2\sigma_w \sigma_{we+C_2}}{\sigma_w^2 + \sigma_{we}^2 + C_2} \\ S(w,we) = \dfrac{\sigma_{wwe+C_3}}{\sigma_w \sigma_{we} + C_3} \end{cases} \quad (14)$$

μ_{wwe} Mean value between w *and* we', σ_{wwe} are covariance between w *and* we [10].

NCC

$$NCC = \frac{\sum_{g=1}^{G} \sum_{h=1}^{H} (WA[g,h] EWE[g,h])}{\sum_{g=1}^{G} \sum_{h=1}^{H} (WA[g,h]^2)} \quad (15)$$

Where WA [g, h] & EWE [g, h] is the watermark image and extracted watermark image.

The range of NCC is 0-1. The value is one i.e no difference between watermark and extracted watermark image [9].

MSE

$$MSE = \frac{1}{X \times Y} \sum_{x=1}^{X} \sum_{y=1}^{Y} [in(x,y) - wd(x,y)]^2 \quad (16)$$

Where in (x, y) is the cover image and wd (x, y) is watermark image [11].

RMSE

This parameter can be computed between watermarked and host image.

$$RMSE = \sqrt{MSE} \quad (17)$$

The RMSE value indicates the quality of the image. The value of RMSE is smaller means the quality of image is good.

Fig 2: (a1) - (d1) are host (cover images), (e1) & (f1) are watermark images, (g1) – (j1) are watermarked images, (k1) – (n1) are extracted watermark VIT images and (o1) – (r1) are extracted watermark cameraman images.

TABLE I. COMPARISION OF QUALITY MEASURES IN TERMS OF PSNR, MSE, RMSE, NCC & SSIM BASED ON WATERMARK VIT IMAGE

Images	PSNR		MSE		RMSE		NCC		SSIM	
	Existing	**Methodology**	Existing	**Methodology**	Existing	**Methodology**	Existing	**Methodology**	Existing	**Methodology**

	ref[12]		ref[12]		ref[12]		ref[12]		ref[12]	
Image (a1)	57.0678	**71.4831**	0.0713	**0.0046**	0.2671	**0.0680**	0.9810	**1.0000**	0.8747	**1.0000**
Image (b1)	61.6249	**71.4832**	0.0294	**0.0046**	0.1714	**0.0680**	0.9810	**1.0000**	0.8747	**1.0000**
Image (c1)	55.6633	**71.4827**	0.1665	**0.0046**	0.4080	**0.0680**	0.9811	**1.0000**	0.8755	**1.0000**
Image (d1)	63.0090	**71.4829**	0.0272	**0.0046**	0.1649	**0.0680**	0.9810	**1.0000**	0.8746	**1.0000**

TABLE II. COMPARISION OF QUALITY MEASURES IN TERMS OF PSNR, MSE, RMSE, NCC & SSIM BASED ON WATERMARK CAMERAMAN IMAGE

Images	**PSNR**		**MSE**		**RMSE**		**SSIM**		**NCC**	
	Existing ref[12]	**Methodology**	Existing ref[12]	**Methodology**	Existing ref[12]	**Methodology**	Existing ref[12]	**Methodology**	Existing ref[12]	**Methodology**
Image (a1)	57.0563	**71.6032**	0.0704	**0.0045**	0.2653	**0.0671**	0.9792	**1.0000**	0.9095	**1.0000**
Image (b1)	62.4401	**71.6034**	0.0253	**0.0045**	0.1589	**0.0671**	0.9792	**1.0000**	0.9094	**1.0000**
Image (c1)	56.4193	**71.6028**	0.1432	**0.0045**	0.3785	**0.0671**	0.9793	**1.0000**	0.9100	**1.0000**
Image (d1)	63.8391	**71.6030**	0.0222	**0.0045**	0.1491	**0.0671**	0.9792	**1.0000**	0.9094	**1.0000**

CONCLUSION

This paper proposed an imperceptible transform domain based digital image watermarking scheme with YUV color space. Firstly, we perform Hadamard transform on Luminance image of color cover image to get coefficient values. The second step is perform embedding operation in between gray level watermark image and Hadamard coefficients of luminance image to obtain embedded image with help of key. Finally to get secrete image at the receiver side after performing the inverse operation of embedding process i.e. extraction process. The proposed algorithm produces better results than the existing method in terms of various quality parameters like PSNR, MSE, RMSE, NCC & SSIM. In future using advanced technologies to improve the watermarking level for providing more security from any unauthorized persons.

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