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An Approach for Image Copyright Protection by using Walsh Hadamard Method

Manish Kumar Gupta[1], Dibakar Raj Pant[2]

[1]*Department of Post Graduate Studies and Research Center, Acme Engineering College*
Purbanchal University, Kathmandu, Nepal
[2]*Department of Electronics & Computer Engineering, Pulchowk Campus*
Institute of Engineering, Tribhuvan University, Kathmandu, Nepal
Corresponding author: pdibakar@gmail.com

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Abstract: Protecting copyrighted image from abuse, misuse and piracy is being critical day by day. Digital image Copyright Protection is considered as a solution to prevent the piracy of original image data. In this article, the authors propose copyright protection method using the well-known Walsh Hadamard transformation along with discrete wavelet transformation and singular value decomposition to achieve robust and imperceptible copyrighted image. The optimum scaling factor which decides the strength of signature image to be embedded is obtained at 0.3. The proposed article ensures imperceptibility of copyrighted image which is determined by Peak signal to noise ratio value greater than 35dB. Normalized Correlation value nearly equals to 0.9999 provides robustness against different attacks such as image cropping, rotations and noise on copyrighted image.

Key words: Walsh Hadamard Transformation, Copyright Protection, Discrete Wavelet Transformation, Singular Value Decomposition,

1. Introduction

Copyrighted image data needs to be protected from misuse or piracy, yet many companies do not focus on management of copyright assets while planning their competitive strategies. One of the techniques used to achieve copyright protection of an image is Digital Watermarking. Digital watermarking is the act of hiding a message related to a digital signal (i.e. an image, song, and video) within the signal itself. Transform Domain Based Watermarking scheme is always a better choice than spatial Domain Based Watermarking Scheme. This can be done using different transformation like Discrete Cosine Transform (DCT), Discrete Wavelet Transformation (DWT), and Singular Value Decomposition (SVD) [1,6,7]. Wavelet transformation is a promising domain for watermark embedding [2]. The Walsh-Hadamard transform is a non-sinusoidal, orthogonal transformation technique that decomposes a signal into a set of basis functions. These basis functions are Walsh functions, which are rectangular or square waves with values of +1 or –1. Hadamard function is binary orthogonal functional corresponding to the two states in digital logic, and therefore more suitable for image processing hardware to achieve a faster rate than another transform. It has been widely used in the area of image processing and image compression.

Until now, various techniques have been proposed for the copyright protection via Digital Watermarking. There is a tradeoff between robustness and imperceptibility of copyrighted image for almost all proposed algorithm until now. As imperceptibility increases, the robustness decreases and vice versa. Thus, existing algorithm should be modified to balance between imperceptibility and robustness. For example, self-reference image watermarking scheme based on DCT and SVD is proposed in [4], Semi-blind watermarking scheme using DWT and DCT is proposed in [6]. Another such algorithm based on SVD, DWT and DCT using Kalman filter is proposed in [1]. All above mentioned algorithms lacks on the balance between imperceptibility and robustness on the copyrighted image. In this article, the authors address the balance between both imperceptibility and robustness property of copyrighted image.

2. Model Formulation

The original image is converted to Luminance (Y), Chrominance-Blue (Cb), Chrominance-Red (CR) color space channels and DWT is applied on Y channel. SVD is applied on a diagonal sub-band (HH). Signature image is embedded by modifying the singular values after applying SVD on HH band. Before applying SVD, Hadamard transformation, DWT on Y channel of the Signature image is performed. Extraction of signature **is** performed by the inversion of watermark embedding process. Using Hadamard Transformation along with DWT and SVD ensure robustness of algorithm.

3. Methods

To obtain the copyrighted image, the signature is embedded into original image. At first the RGB image is converted to YCbCr. The conversion can be obtained from the following equations:

$$\begin{aligned} Y &= 0.299R + 0.587G + 0.114B \\ Cb &= 0.59 - 0.272G - 0.321B \\ Cr &= 0.212R - 0.523G - 0.311B \end{aligned} \tag{3.1}$$

The 4-level DWT is applied on Y Color channel to sub divide the image into Approximation Sub band (LL4), Vertical Sub band (LH4), Horizontal Sub band (HL4) and Diagonal Sub band (HH4). The 2 level DWT can be shown as:

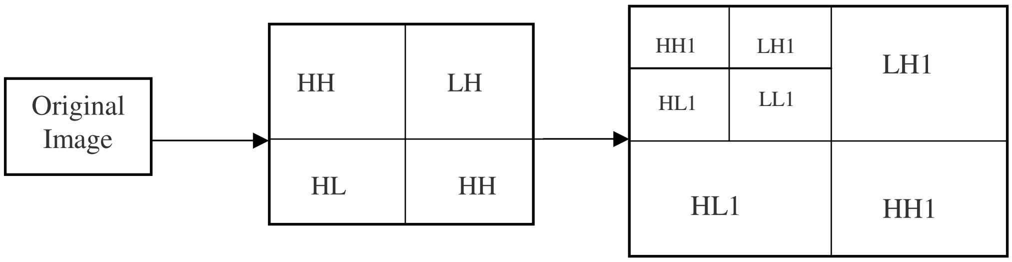


Fig 3.1: DWT Decomposition of the Image

Singular Value Decomposition transform is applied on HH4 resulting into three different singular matrices shown by equation:

$$M = USV^{T} \tag{3.2}$$

Similar technique is performed on the signature image; the difference is to apply Hadamard Transformation to signature image to scramble it for potential toleration for various attacks on image. H (0, 0) is called image block the DC component Hadamard transformation domain. Using an interactive relationship can generate higher order transform matrix of Hadamard transform, given in the Equation (3.3) below:

$$H_2 = \begin{bmatrix} +1 & +1 \\ +1 & -1 \end{bmatrix}, \quad H_{2^{k+1}} = \begin{bmatrix} H_{2^K} & H_{2^K} \\ H_{2^K} & -H_{2^K} \end{bmatrix}, k = 1,2,3......k \tag{3.3}$$

The 3-level DWT is applied to obtain the diagonal sub band of scrambled signature image and singular value decomposition is performed. The singular value of signature image is scaled by optimum value of scaling factor of 0.3. The singular values of original image are replaced by modified singular values of signature image. The content of signature image is now embedded in diagonal sub band of Original image.

The Y channel of copyrighted image is obtained by applying inverse Discrete Wavelet Transform along with inverse Singular Value Decomposition. The Y channel is combined with previous Cb and Cr channels of copyrighted image and converted back to RGB to get imperceptible copyrighted image.

To deal with the ownership of Copyrighted image, the original signature image should be extracted from the signed image. For this, the copyrighted image is converted to YCbCr channels using the equation (3.1). After applying 4-level DWT on Y channel the singular values are obtained. The singular values are divided by scaling factor which is used during embedding process. The modified singular values obtained is combined with left and right singular matrices of signature image to get the SVD component of signature image. After applying inverse 3-Level DWT the Scrambled Y channel is obtained. The inverse Hadamard Transformation is performed to obtain the original Y channel of signature image. The final process of YCbCr to RGB conversion is performed to get the extracted signature.

4. Results and Discussion

To implement this technique, different standard test images of size 512x512 are used as the original and image of size 256x256 is used as the signature image. The standard original image of sailboat is taken from The USC-SIPI Image Database [8].The simulation results demonstrate the imperceptibility of the proposed algorithm by measuring Mean squared error (MSE), NC, PSNR and Structural Similarity Index (SSIM) between original image versus copyrighted image and between signature image versus extracted signature image.

(a)

(b)

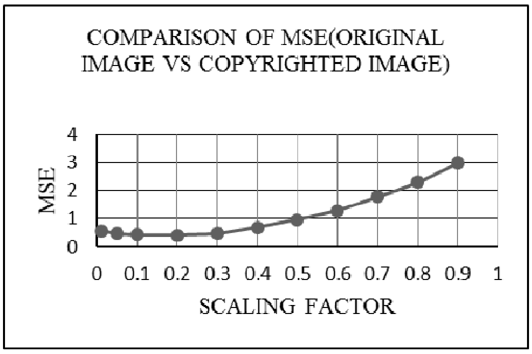
Fig. 4.1: (a) Sailboat Standard **Image,** **(b) Signature Image**

Imperceptibility property can be described as the characteristic of hiding a signature image so that it does not degrade the visual quality of the original image. Imperceptibility is measured via performance measure like PSNR and MSE. Higher the PSNR value better is the image quality. When PSNR is higher than 35 dB, copyrighted image has a very good quality and the human visual system could hardly distinguish between the original and the copyrighted image.

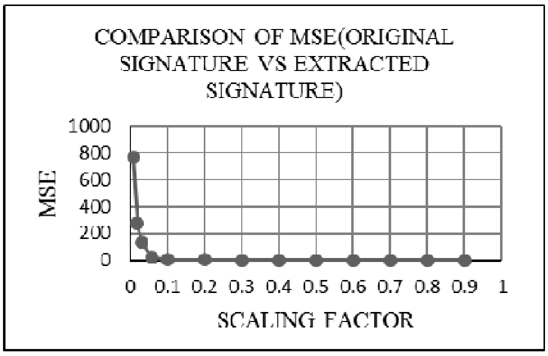
Table 4.1 Performance Measures of signing and extraction for Sailboat image

Sailboat image								
Scaling Factor	MSE (Embedding)	MSE (Extraction)	PSNR (Embedding) (dB)	PSNR (Extraction) (dB)	NC Image	NC-Signature	SSIM-Image	SSIM-signature
0.01	0.563	774.6053	50.625	19.2399	0.9999	0.9917	0.9991	0.6562
0.03	0.5161	127.1487	51.0028	27.0876	0.9999	0.9986	0.9991	0.9037
0.05	0.4802	39.6617	51.3164	32.147	0.9999	0.9995	0.9991	0.9575
0.07	0.461	16.3603	51.4932	35.9928	0.9999	0.9998	0.9991	0.9787
0.09	0.4402	7.2581	51.6936	39.5225	0.9999	0.9999	0.9991	0.9905
0.1	0.4273	0.9796	51.8227	48.2199	0.9999	0.9999	0.9991	0.9982
0.2	0.4168	0.5653	51.9309	50.6076	0.9999	0.9999	0.9991	0.9994
0.3	0.479	0.3115	51.3266	53.1952	0.9999	0.9999	0.9991	0.9997
0.4	0.6789	0.2963	49.8125	53.4122	0.9999	0.9999	0.9991	0.9998
0.5	0.9595	0.3112	48.3099	53.199	0.9999	0.9999	0.9991	0.9997
0.6	1.2818	0.3057	47.0525	53.2777	0.9999	0.9999	0.9991	0.9997

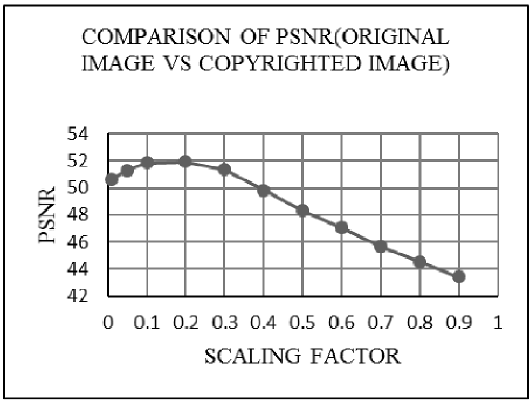
0.7	1.772	0.298	45.6461	53.3881	0.9999	0.9999	0.9991	0.9997
0.8	2.2968	0.2908	44.5195	53.4948	0.9999	0.9999	0.9991	0.9998
0.9	2.9644	0.3057	43.4114	53.2777	0.9999	0.9999	0.9991	0.9997



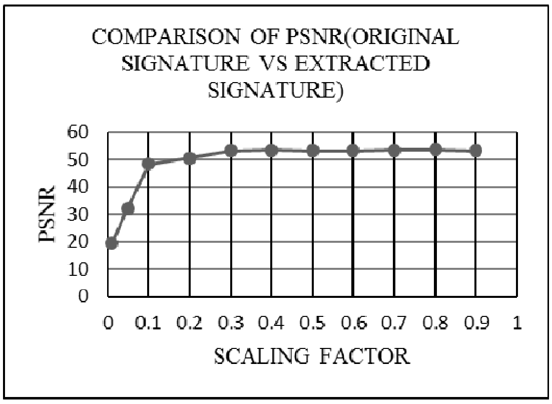
(a)



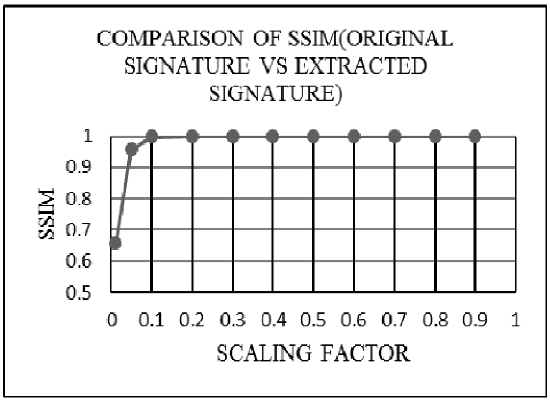
(b)



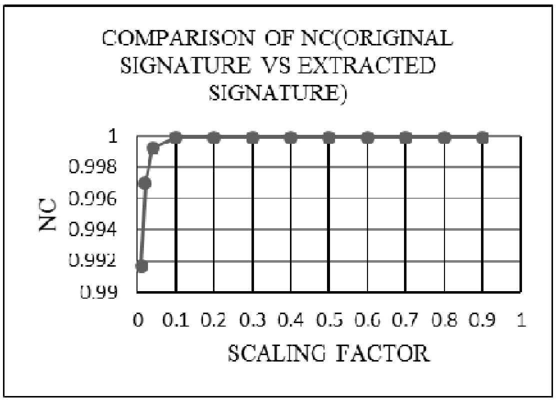
(c)



(d)



(e)



(f)

Fig 4.2 (a), (b) Chart of MSE values for Sailboat **image**
(c), (d) Chart of PSNR values for Sailboat **image**
(e) Chart of SSIM values for Sailboat image
(f) Chart of NC values for Sailboat image

Table 4.2 Optimum scale factor for Sailboat Image

Original Image	Scaling Factor	MSE (Signing)	MSE (Extraction)	PSNR(dB) Signing	PSNR(dB)-Extraction	NC-Image	NC-Signature	SSIM-Image	SSIM-signature
Sailboat	0.3	0.479	0.3115	51.3266	53.1952	0.9999	0.9999	0.9991	0.9997

To test the robustness of the proposed algorithm, different geometric attacks are performed on the Copyrighted image. Robustness of image is tested by comparing similarity of extracted Signature image with original Copyrighted image. Similarity of watermarks are carried out on the basis of NC. The PSNR**,** MSE and SSIM are also calculated. The table 4.3 shows different attacks carried out on standard sailboat Copyrighted image.

Table 4.3 Performance Measures after different geometric attacks

Attacks	Sailboat Image			
	MSE	PSNR	NC	SSIM
Grayscale Attack	0.5746	50.5365	0.9999	0.9994
Image Sharpening	4.5254	41.5741	0.9999	0.9964
Compression Quality 10%	12.4291	37.1864	0.9998	0.9938
Compression Quality 20%	12.4291	37.1864	0.9998	0.9938
Compression Quality 30%	12.4291	37.1864	0.9998	0.9938
Compression Quality 40%	12.4291	37.1864	0.9998	0.9938
Gaussian Noise	13.0302	36.9812	0.9998	0.9797
Rotate and Crop	6.2395	40.1792	0.9999	0.9965
Rotate BY 90	0.5653	50.6076	0.9999	0.9994
Rotate BY 180	0.5653	50.6076	0.9999	0.9994
Motion Blur Attack	11.7263	37.4391	0.9998	0.9941
Trimming Attack	0.5706	50.5673	0.9999	0.9994
Mirror Flip Attack	0.5653	50.6076	0.9999	0.9994

5. Conclusion

To evaluate the performance of algorithm, optimum value of performance measures is calculated at scaling factor of 0.3 which depends on the type of images being used**.** Standard image processing test image is taken for testing the imperceptibility of the algorithm**.** To test the robustness of the algorithm different geometric attacks are carried out on signed image and then signature is extracted. With the value of PSNR greater than 35dB that defines the imperceptibility, the cover image and Copyrighted image are visually same. The value of NC equals to 0.9999 that defines the robustness, after different geometric attacks, shows the high similarity between the original watermark and extracted watermark.

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