A WAVELET BASED COPYRIGHT MARKING ON IMAGE UNDER SUB-BANDS STACKING TECHNIQUE

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***Abstract*—–Watermarking of multimedia gives more attention to the research society. This paper presents the non-blind watermarking technique; initially, a watermark is reshaped and grouped into odd and even row images. Next, two-level decomposition is imposed on an original image, and to enrich the robustness of the technique, LL_2 band which is divided into two shares and stack with LH_1. The copyright marking process is enabled in the lower diagonal regions of stacked sub-bands wavelet coefficients. Next, the merge sub-bands are back to the original position, inverse wavelet is imposed to obtain the marked cover image. To prove authorship the cover and copyrighted image has subject to the same procedure and acquires the marked information.**

***Keywords*—– Authentication, Copyright protection, Watermarking, Wavelet Transform, Sub-band stacking**

I. INTRODUCTION

The enormous growth of multimedia communication is indicated that digital content is easily spread. While spreading unknown can claim authorship, in this view protecting the digital content is notable consideration for today's scenario (Li and Cox, 2007; Chen *et al*., 2009; Piva *et al.*, 2010).In this aspect, the protection of digital data and control is a vital task (Arnold *et al*., 2003). Since the digital multimedia information has zero difference between the excellence of an original and its copy (Huang *et al*., 2007). Researchers have been drilled down the solutions for copyright protection. The multimedia information which ensured against illegal transmission and protection is enabled only by the identification mark which is assigned by the owner.

A scheme that tends to install the copyright data into the digital media is called Watermarking. A person cannot visualize the identification mark with an eye and perceives it as a normal cover medium (Podilchuk and Delp, 2001). Copyright marking has secured numerous attention while giving the integrity and authenticity of the owner (Piva *et al.*, 2002; Potdar *et al.*, 2005; Wang *et al*., 2002; Sridhar, 2019). Hence the industry and academic people are working seriously on digital watermarking (Mohanty *et al*., 2017, Horng *et al*., 2013). Watermarking techniques require three features like confidentiality, reliability, and availability. Confidentiality indicates that only authorized people can access the data. Reliability may be sectioned into two aspects: i) Integrity which

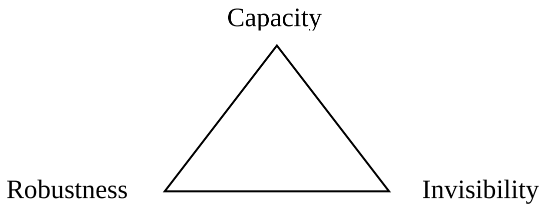


Fig.1. Features of watermarking system

can ensure that the information has not been changed, ii) Authentication which verifies that the data from the verified source. Finally, Availability defines the capability of the authorized users to utilize the information system.

The two different embedding approaches in watermarking systems are spatial and transform domain (Shih and Wu, 2003). In the spatial watermarking technique, it is easy to install the copyright data into an original by modifying the values of pixel straightforwardly using bit substitution. Copyright mark is fetched into the transform coefficients in the transform domain, hence these approaches deserve more robust and stable (Sridhar and Arun, 2016). Any watermarking technique has to be evaluated based on the following requirements (Huang and Wu, 2004):

Capacity: The bunch of data that has to fetch in the host data. Generally, it is subject to the scheme employed for copyright marking.

Robust: A marking approach is called robust it is capable to safeguard the secret information even various noise, filtering, and geometrical attacks.

Invisibility: A watermarking scheme is said to better invisibility property if we are unable to highlight the modifications in the cover medium after fetching of the watermark. This requirement is represented as a trade-off triangle as shown in Fig. 1. Any algorithms can satisfy the two out of three properties, and then the third one should be traded off.

The remaining section is organized as follows, literature review involves Section II. The proposed method and the results are discussed in Sections III and IV. Finally, a conclusion is placed in Section V.

II. EXISTING APPROACHES

This section puts forward the existing algorithms in the scientific review. A zero loss and effective marking approach based on a hybrid of SVD and visual cryptography under the domain of wavelet (Ali *et al*., 2017). The estimation of change in the invariant domain of the original image can be achieved by the fractional Fourier transforms and wavelet (Rawat and Raman 2012). In order to fetch the watermark data, identified the random position of the transformed matrix. The largest Singular values are deserved to install the copyright data because of the energy of the most perceptually significant regions in the image. This scheme is more secure and less computational time than other existing techniques.

Watermarking approach is enabled by the hybrid structure of DFT and compressive sensing technique is presented (Liao *et al.*, 2017), DFT is carried out on the host image, in this encryption scheme has done in a most significant part of the transformed image and watermarking is in another part of the transformed image. The performance measure can be observed in terms of PSNR and BER. This method holds better performance than other recent reported techniques (Wang *et al.*, 2001). However, the proposed method takes more time for encryption and watermarking.

Watermarking techniques can be focused on the features like robustness, imperceptibility, capacity (Gunjal and Mali, 2015). In non-blind detection, the technique has secured an excellent embedding capacity with strong security features. The excellence of this technique is compared and found better in terms of security of data and computation time than existing approaches. Multiple watermarking techniques are described by the combination of Integer Discrete Wavelet Transform (IDWT) and SVD (Lei *et al.*, 2017). Copyright data are fetched into selective IDWT sub-bands of the host image. In order to find the optimal parameter selection, artificial bee colony (ABC) algorithm have been developed. Simulation results indicate that the superiority of the proposed technique as compared to other state-of-the-art methods.

Security requirements of multimedia information are mostly derived from the ethics of the security policy. Evaluating these reviews identified that marking a region of copyright data place a vital role, hence this approach gives the direction to implant a watermark in the subband stacking region.

III. PROPOSED APPROACH

In the proposed approach, the cover image Y and it undergoes a two-level wavelet transform. Further, the LL_2 band and LH_1 band are undergone the alternative pixel share image. Where $i = 1,2,\dots,m$ and $j = 1,2,\dots,n$. The Eq. 1 represents the single level decomposition. Figure 2 highlights the marking region under wavelet.

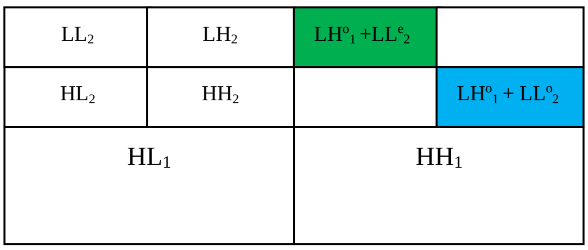


Fig. 2. Sub-band stacking and marking region of copyright information

$$[Y]_{xXy} \xrightarrow{DWT} \begin{bmatrix} Y_{ll_2} & Y_{lh_2} & \\ Y_{hl_2} & Y_{hh_2} & Y_{lh_1} \\ & Y_{hl_1} & Y_{hh_1} \end{bmatrix} \quad (1)$$

The Eqs. 2 and 3 show the alternative pixels share.

$$Y^o_{ll_2}(k,l) = \begin{cases} Y_{ll_2}(i,2j), \text{if} \frac{i}{2} = 0, j = 1,2,\cdots,\frac{n}{2}, \\ \qquad k = i \text{ and } l = 2j \\ Y_{ll_2}(i,2j-1), \text{if} \frac{i}{2} \neq 0, j = 1,2,\cdots,\frac{n}{2}, \\ \qquad k = i \text{ and } l = 2j-1 \end{cases} \quad (2)$$

$$Y^e_{ll_2}(k,l) = Y_{ll_2}(m,n) - Y^o_{ll_2}(k,l) \quad (3)$$

$$Y^o_{lh_1}(u,v) = \begin{cases} Y_{lh_1}(i,2j), \text{if} \frac{i}{2} = 0, j = 1,2,\cdots,\frac{n}{2}, \\ \qquad u = i \text{ and } v = 2j \\ Y_{lh_1}(i,2j-1), \text{if} \frac{i}{2} \neq 0, j = 1,2,\cdots,\frac{n}{2}, \\ \qquad u = i \text{ and } v = 2j-1 \end{cases} \quad (4)$$

The above Eq. 4 represents the sharing of medium level sub-band. Also $Y^e_{lh_1}(u,v)$ can be obtained by subtracting the $Y^o_{lh_1}(u,v)$ from $Y_{lh_1}(u,v)$. Where $u = 1,2,\dots,2m$ and $v = 1,2,\dots,2n$, now stack the two-level low frequency subbands with single level middle level subbands. Consider a watermark $[W]_{rXc}$ and it is reshaping in to row image $[W_R]_{1Xr*c}$. Next, it is grouped to only odd and even column elements $[W_R(i,2j-1)]_{1Xr*c}$ and $[W_R(i,2j)]_{1Xr*c}$ The Eq. 5 illustrates the odd column and even column watermark elements.

$$[W_R(i,j)]_{1Xr*c} = \begin{cases} [W_E(p,q)]_{1X\frac{r*c}{2}}, \text{if } mod(j,2) \neq 0, p = i, \\ \qquad \text{and } q = \frac{i+j}{2} \\ [W_O(p,q)]_{1X\frac{r*c}{2}}, \text{if } mod(j,2) = 0, p = i, \\ \qquad \text{and } q = j \end{cases} \quad (5)$$

where $i = 1$ and $j = 1,2,\dots r*c$. The watermarking process is enabled only in the lower diagonal regions of stacked sub-bands. The below equations represent the watermark embedding process. Where d is the length of the watermarking process, the following equations satisfy the conditions of watermarking techniques in lower diagonal regions. Where α and β are scaling factors that reduce the weight of the watermark signal. The Eqs. 6 and 7 indicate the embedding conditions in cross-layered fashion.

Condition 1:

$$S^w_1(i,j) = Y^o_{lh_1}\left(1{:}\frac{u}{2}, 1{:}\frac{v}{2}\right) + Y^e_{ll_2}(k,l) + \alpha W_o(z) \quad (6)$$

$$d = \left(\frac{u}{2} + \frac{v}{2} - 1\right), \dots, 2,1;\ i + j = d + 1 \text{ and}$$
$$z = 1,2,\dots,\frac{r*c}{2}$$

Condition 2:

$$S^w_2(i,j) = Y^o_{lh_1}\left(\frac{u}{2}{:}u, \frac{v}{2} + 1{:}v\right) + Y^o_{ll_2}(k,l) + \beta W_e(z) \quad (7)$$

$$d = (u + v - 1), \dots, 2,1;\ i + j = d + 1 \text{ and}$$
$$z = 1,2,\dots,\frac{r*c}{2}$$

After embedding, the stacked sub-bands are bringing back to the original positions and merged with non-watermarked shares. The below Eqs. 8 and 9 show the isolation of watermarked LL_2 sub-bands.

$$Y^{ow}_{ll_2}(k,l) = \begin{cases} S^w_1(i,2j), \text{if} \frac{i}{2} = 0 \text{ and } j = 1,2,\cdots,\frac{n}{2}, \\ \qquad k = i \text{ and } l = 2j \\ S^w_1(i,2j-1), \text{if} \frac{i}{2} \neq 0 \text{ and } j = 1,2,\cdots,\frac{n}{2}, \\ \qquad k = i \text{ and } l = 2j-1 \end{cases} \quad (8)$$

$$Y^{ew}_{ll_2}(k,l) = \begin{cases} S^w_2(i,2j), \text{if} \frac{i}{2} \neq 0 \text{ and } j = 1,2,\cdots,\frac{n}{2}, \\ \qquad k = i \text{ and } l = 2j \\ S^w_2(i,2j-1), \text{if} \frac{i}{2} = 0 \text{ and } j = 1,2,\cdots,\frac{n}{2}, \\ \qquad k = i \text{ and } l = 2j-1 \end{cases} \quad (9)$$

$$Y^w_{ll_2}(k,l) = Y^{ew}_{ll_2}(k,l) + Y^{ow}_{ll_2}(k,l) \quad (10)$$

$$Y^w_{lh_1}(u,v) = Y^{ow}_{lh_1}(u,v) + Y^e_{lh_1}(u,v) \quad (11)$$

$$\begin{bmatrix} Y^w_{ll_2} & Y_{lh_2} & \\ Y_{hl_2} & Y_{hh_2} & Y^w_{lh_1} \\ & Y_{hl_1} & Y_{hh_1} \end{bmatrix} \xrightarrow{IDWT} [Y^W]_{xXy} \quad (12)$$

The above Eqs. 10 and 11 show the formation of watermarked sub-bands. Finally, an inverse wavelet is imposed to obtain the watermarked image Y^W which is represented in Eq. 12.

$$W_{RO}(p,q) = \frac{S^w_1(i,j) - Y^e_{ll_2}(k,l)}{\alpha} \quad (13)$$

$$W_{RE}(p,q) = \frac{S^w_2(i,j) - Y^o_{ll_2}(k,l)}{\beta} \quad (14)$$

$$W' = W_{RO}(p,q-1) + W_{EO}(p,2q) \quad (15)$$

with $p = 1, q = 1, \ldots, \frac{r*c}{2}$.

To prove the ownership of multimedia content, copyright data has to be extracted. Since this approach is non-blind hence original image is required to extract the same. The above Eqs. 13 and 14 represent the extraction of watermark and the Eq. 15 shows the formation of watermark image. Finally, reshape the row image into normal form to obtain the copyright image.

IV. RESULTS AND DISCUSSION

The excellence of this technique is executed by using MATLAB. For implanting the copyright information, standard images like the Lena, Baboon, Cameraman, rice of size 256x256 can be utilized and the watermark information of size 64x64. Figure 3 illustrates the test images for implementing this algorithm. Figure 4 displays the sub-band stacking between the LL_2 and LH_1.

The difference value between the watermarked image and original image can evaluate by Mean Square Error, it is denoted as

$$MSE = \left(\frac{1}{XY}\right) \sum_{x,y} (A(x,y) - O(x,y))^2 \quad (16)$$

Peak signal to noise ratio (PSNR) is used to measure the quality of the watermarked image.

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right) \quad (17)$$

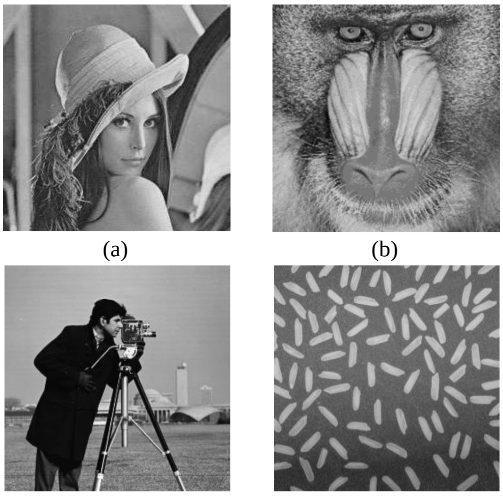
The above Eqs. 16 and 17 show the MSE and PSNR respectively. In this approach the PSNR values of watermarked image and an extracted watermark are 61.2661dB and 32.5412 dB respectively. The time consumed to fetch the watermark is only 2.5289 seconds. Figure 5 shows the original cover image, copyright image, copyrighted cover image and extracted watermark. Figure 6 displays the comparison sketch between the wavelets and the hybrid approach. Table 1 shows the different PSNR values concerning the scaling factor and the Daubechies wavelet in the order db2 and db4.

A hybrid approach of DWT and SVD is encountered on this method; Table 2 shows the comparison results. In this DWT acquired better performance than a hybrid approach. The proposed approach has secured a higher PSNR value than Meenpal (2018) is 46 dB and Tanwar and Khurana (2016) is 37.676 dB. The common attacks of watermarking approaches are noise, filtering, and geometrical attacks. In this proposed algorithm, various noises include Salt and Pepper, Speckle and Gaussian with default noise density. In addition to that median filtering, attacks are incorporated in copyrighted images. Similarly, geometric attacks like rotation and cropping attacks are also imposed to the watermarked images in order to estimate the robustness of our system. Table 3 shows the performance analysis with different attacks.

The outcome of the present work lies in securing the digital contents from the illegal operations such as copying, modification, forgery, and also to avoid the una-

Table 1: Performance measures of Scaling factor with wavelets

Scaling Factor	Lena		Baboon		Cameraman		Rice	
	Db2	Db4	Db2	Db4	Db2	Db4	Db2	Db4
	PSNR (dB)	PSNR (dB)	PSNR (dB)	PSNR (dB)	PSNR (dB)	PSNR (dB)	PSNR (dB)	PSNR (dB)
0.01	57.9294	62.5594	61.6510	62.1768	60.5331	60.7751	59.8416	59.5533
0.02	57.8985	59.6977	55.1189	57.2944	61.2474	58.7264	58.4113	59.8692
0.03	57.0226	58.3174	55.5897	57.5897	56.3848	57.3848	56.5648	58.9962
0.04	56.6065	58.9969	56.4335	57.4769	55.2891	57.9194	55.5695	58.2885
0.05	55.7424	56.1227	55.3782	56.3024	54.8441	56.8858	54.2509	55.6603
0.06	53.9329	55.2315	51.4484	54.6489	52.3614	54.2739	53.2077	54.2461
0.07	52.1116	53.9457	51.9209	53.4667	51.4738	52.9728	51.2109	52.2884
0.08	51.9853	52.0471	49.6649	52.0944	50.1636	52.3783	51.9318	52.5579
0.09	50.2254	51.2254	49.8222	50.8222	50.8517	51.8517	50.9743	51.9743
0.1	50.4360	51.1496	49.5767	50.0547	49.1430	51.6159	50.5303	50.5622



(a) (b) (c) (d)

Fig. 3 (a) Lena; (b) Baboon; (c) Cameraman; (d) Rice.

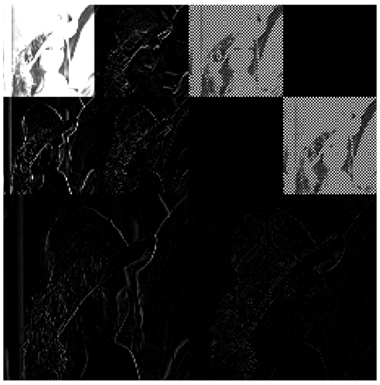
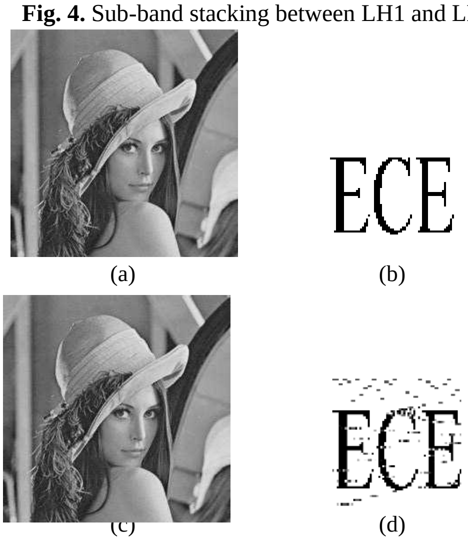


Fig. 4. Sub-band stacking between LH1 and LL2



(a) (b) (c) (d)

Fig. 5. (a) Original Image; (b) Watermark image; (c) Watermarked Image; (d) Extracted Watermark.

thorized copy of digital documents. Moreover, the present work shows that the high degree of invisibility and robustness against attacks. The proposed method gives the idea of surveillance services, which benefit the users commercially.

V. CONCLUSION

In this paper, the optimal and robust region marking for high security is proposed. Here, merged the different degrees of sub-band and the copyright is fetched in the cross-layered fashion of lower diagonal region under wavelet coefficients, hence the achievable rate of robustness is high. PSNR and MSE of this method are 61.2661dB and 0.1312. This method is efficient and highly robust. The future research direction is planned to implement this algorithm on video.

Table 2: Comparison table between DWT and Hybrid approach

Scaling factor	Db2 PSNR(dB)	Db4 PSNR(dB)	DWT-SVD PSNR(dB)
0.01	59.9887	61.2661	59.3493
0.02	58.1690	58.8969	57.9938
0.03	56.3905	58.0720	55.3479
0.04	55.9746	58.1704	55.8374
0.05	55.0539	56.2428	53.7365
0.06	52.7376	54.6001	52.8374
0.07	51.6793	53.1684	51.3798
0.08	50.9364	52.2694	51.8739
0.09	50.4684	51.4684	49.3749
0.1	49.9215	50.8456	48.3347

Table 3: Performance analysis with various attacks

Attacks	Lena	Baboon	Cam-era-man	Rice
	PSNR (dB)	PSNR (dB)	PSNR (dB)	PSNR (dB)
No attacks	62.5594	62.1768	60.7751	59.5533
Median	34. 9385	33.9969	33. 5796	32.1903
Salt & Pepper	27.2934	27.4506	26. 4434	25.6950
Speckle	29. 1346	28.9866	27.8759	26.7894
Gaussian	25.5654	25.0966	24.4506	24.3723
Rotation	24. 9507	24.7096	23.8275	23.5097
Cropping	25. 5991	24.5965	23.5065	22.0954

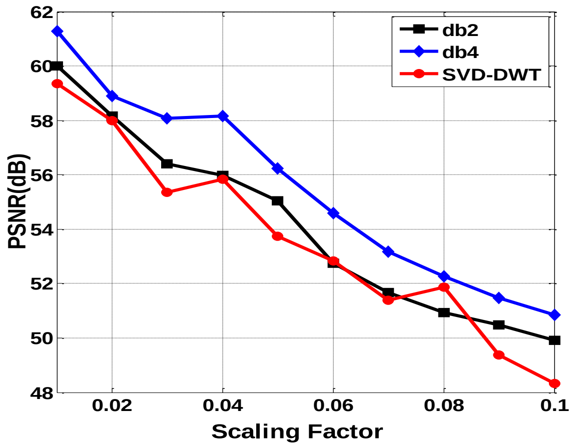


Fig. 6. Comparison sketch between wavelets and hybrid approach.

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