Robust Watermarking Using Dwt-Svd & Torus Automorphism (DSTA) Based With High PSNR

Prateek Shrivastava, SRIST, Jabalpur
Md.Suhel, SRIST, Jabalpur

Abstract: Proposed work is another arrangement of picture watermarking which join pre-preparing of cover picture with DWT and SVD, Proposed work using an alphanumeric key which at first alters watermark using fundamental 'XOR' operation, and at beneficiary end this key must be there so recipient may remove watermark. Proposed work is moreover using torus Automorphism which at first change watermark into a scramble plan which can't be affirmation as remarkable watermark. Case picture from database has been picked as cover picture and host picture. Viability of figuring took a gander at by using parameter, for example, PSNR, BER and MSE. It has been found that PSNR upgrade by 10.64%. This exhibits capability of computation. The work is been design and attempted on MATLAB 2013 test framework

Keywords: DWT: Discrete Wave Transform, SVD: Singular Value Decomposition, TA: Torus Automorphism, AS: Arnold scrambling, LL: rough band, LH: Vertical Band, HL: Horizontal band, HH: askew detail band

I-INTRODUCTION

There are a few picture watermarking plans with a test to give both perceptual quality and in addition power against assaults, as these two measures struggle with each other. As indicated by the area of installing, there are two kinds of watermarking plans - spatial space and change space based watermarking plans. Spatial area watermarking plans install watermark by changing pixels of host picture, while change space plans insert watermark in change space coefficients.

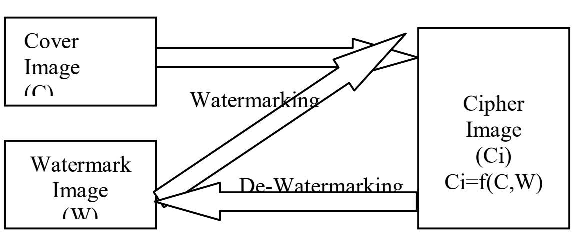

Figure 1 watermarking hiding scenario

The major problems of secure data communication are as follow:-
Watermarking is an overhead for communication system it is requires just to secure data but not necessary for data communication. In watermarking the measure of cover picture must be high than watermark picture. We can't utilize same calculation for all kind of cover picture and watermark. In watermarking the ideal opportunity for concealing watermark ought to be sufficiently low so it doesn't bother correspondence. To start with issue is to keep up adjust between subtlety, heartiness and limit as expanding one factor unfavorably influence on other and a decent computerized watermarking framework have above element. To accomplish great intangibility, watermark ought to be implanted in high recurrence segment though vigor happens in low recurrence segment.

II-METHODOLOGY

Proposed work is another outline of picture watermarking which incorporate first pre-handling of cover picture with DWT and SVD. DWT based watermarking can be versatile and as cover picture changes, its frequencies likewise get changes so the watermark picture additionally get stows away at various areas and spread at various areas. SVD is been connected for concealing bits of watermark and SVD is been taken of 8x8 piece which shroud a solitary piece of watermark at 64 diverse particular estimations of each square, in light of SVD affect all sort of correspondence assaults like tweak, clamor, pressure and channel can be abstained from, Changing SVs somewhat does not influence the nature of the flag and if nature of flag changes because of some other reason SVs still get marginally change as contrast with different specimens of flag. So if in correspondence some of SVs changes our singles bit which is covered up at

8x8=64 SVs areas still can be recouped. Proposed work utilizing an alphanumeric key which at first alters the watermark utilizing straightforward 'XOR' operation, and at the collector end this key must be there so recipient can remove the watermark. Proposed work is likewise utilizing torus Automorphism which at first change the watermark into a scramble organize which can't be acknowledgment as unique watermark, this gives additional security of the watermark and if some interloper recoup watermark from cover picture, he will get a scramble watermark which will additionally expected to get in its unique shape.

ALGORITHM ADOPTED FOR WATERMARKING: Let C is the cover image of MxN size and W is the watermark image of PxQ size, DWT applied on ‘C’, proposed work use ‘sym4’ type wavelet for decomposition of Cover image

Sym 4	h_0 = -0.0757657148, h_1 = -0.0296355276 h_2 = 0.4976186676, h_3 = 0.8037387518 h_4 = 0.2978577956, h_5 = -0.0992195436 h_6 = -0.0126039673, h_7 = 0.0322231006	g_0 = -0.0322231006, g_1 = -0.0126039673 g_2 = 0.0992195436, g_3 = 0.2978577956 g_4 = -0.8037387518, g_5 = 0.4976186676 g_6 = 0.0296355276, g_7 = -0.0757657148

Figure 2 DWT HP and LP coefficient generation

$$x(n)_L = \sum_{k=-\infty}^{\infty} x(k)g(2n-k) \quad (1)$$

$$x(n)_H = \sum_{k=-\infty}^{\infty} x(k)h(2n-k) \quad (2)$$

Where g and h coefficients taken from the table 3.1. DWT2 is use for Images for two dimension DWT, hence $x(n)_L$ and $x(n)_H$ further need to filtered as below

$$x(n)_{LL} = \sum_{k=-\infty}^{\infty} x(n)_L g(2n-k) \quad (3)$$

$$x(n)_{LH} = \sum_{k=-\infty}^{\infty} x(n)_L h(2n-k) \quad (4)$$

$$x(n)_{HL} = \sum_{k=-\infty}^{\infty} x(n)_H g(2n-k) \quad (5)$$

$$x(n)_{HH} = \sum_{k=-\infty}^{\infty} x(n)_H h(2n-k) \quad (6)$$

Equation (3), (4), (5) and (6) are the level one DWT decomposition

$$x(n)_{HHH} = \sum_{k=-\infty}^{\infty} x(n)_{HH} g(2n-k) \quad (7)$$

$$x(n)_{HHL} = \sum_{k=-\infty}^{\infty} x(n)_{HH} h(2n-k) \quad (8)$$

$$x(n)_{LL1} = \sum_{k=-\infty}^{\infty} x(n)_{HHL} g(2n-k) \quad (9)$$

$$x(n)_{LH1} = \sum_{k=-\infty}^{\infty} x(n)_{HHL} h(2n-k) \quad (10)$$

$$x(n)_{HL1} = \sum_{k=-\infty}^{\infty} x(n)_{HHH} g(2n-k) \quad (11)$$

$$x(n)_{HH1} = \sum_{k=-\infty}^{\infty} x(n)_{HHH} h(2n-k) \quad (12)$$

Equation (9), (10), (11) and (12) are the level one DWT decomposition

► Approximation coefficients

► Detail coefficients

$$x(n)_{HH1H} = \sum_{k=-\infty}^{\infty} x(n)_{HH1} g(2n-k) \quad (13)$$

$$x(n)_{HH1L} = \sum_{k=-\infty}^{\infty} x(n)_{HH1} h(2n-k) \quad (14)$$

Equation (9), (10), (11) and (12) are the level one DWT decomposition

$$x(n)_{LL2} = \sum_{k=-\infty}^{\infty} x(n)_{HH1L} g(2n-k) \quad (15)$$

$$x(n)_{LH2} = \sum_{k=-\infty}^{\infty} x(n)_{HH1L} h(2n-k) \quad (16)$$

$$x(n)_{HL2} = \sum_{k=-\infty}^{\infty} x(n)_{HH1H} g(2n-k) \quad (17)$$

$$x(n)_{HH2} = \sum_{k=-\infty}^{\infty} x(n)_{HH1H} h(2n-k) \quad (18)$$

Equation (15), (16), (17) and (18) are the level one DWT decomposition

Size of $\boldsymbol{x(n)_{HH}}$ is (MxN)/4 size and $\boldsymbol{x(n)_{HH1}}$ is (MxN)/16 and $\boldsymbol{x(n)_{HH2}}$ is (MxN)/64, Let size of $\boldsymbol{x(n)_{HH2}}$ is RxS where R=M/8 and S=N/8. SVD taken of 8x8 block of $\boldsymbol{x(n)_{LL2}}$, $\boldsymbol{x(n)_{LH2}}$, $\boldsymbol{x(n)_{HL22}}$ ***and*** $\boldsymbol{x(n)_{HH2}}$ means at each DWT decomposed level $\boldsymbol{x(n)_{LL2}}$, $\boldsymbol{x(n)_{LH2}}$, $\boldsymbol{x(n)_{HL22}}$ ***and*** $\boldsymbol{x(n)_{HH2}}$ will have total RxS/64 SVD. We total 4 $\boldsymbol{x(n)_{LL2}}$, $\boldsymbol{x(n)_{LH2}}$, $\boldsymbol{x(n)_{HL22}}$ ***and*** $\boldsymbol{x(n)_{HH2}}$ components after three level DWT decomposition. Means (RxS/64)x4 watermark bit can be hide. And as known R=M/8 and S=N/8

$$\begin{aligned}&total\ numbet\ of\ watermark\ bit\ that\ can\\ &be\ hide\ in\ cover = \frac{RxSx4}{64} = \frac{MxNx4}{8x8x64} = \frac{MxN}{1024}\end{aligned}$$

Here we are explaining the Calculation of SVD for $\boldsymbol{x(n)_{HH2}}$ only although it is been computed for all 8x8 block of $\boldsymbol{x(n)_{LL2}}$, $\boldsymbol{x(n)_{LH2}}$, $\boldsymbol{x(n)_{HL22}}$ ***and*** $\boldsymbol{x(n)_{HH2}}$

Let B1 is the first 8x8 block of $\boldsymbol{x(n)_{HH2}}$. the singular value decomposition of an 8x8 real matrix B1 is a factorization of the form $\boldsymbol{USV^T}$, where U is an 8x8 real matrix, S is a 8x8 rectangular diagonal matrix with non-negative real numbers on the diagonal, and V is an 8x8 real or complex unitary matrix. The diagonal entries $\boldsymbol{\sigma_i}$ of S are known as the singular values of B1. The columns of U and the columns of V are called the left-singular vectors and right-singular vectors of B1, respectively.

$$W1 = B1xB1^T \qquad (W1 - \sigma_i I) = 0 \qquad (19)$$

For a unique set of eigenvalues to determinant of the matrix (W1-$\boldsymbol{\sigma_i}$) must be equal to zero. Thus from the solution of the characteristic equation, |W1-$\boldsymbol{\sigma_i}$|=0 we obtain eight singular values of $\boldsymbol{\sigma_i}$ ***where*** $\boldsymbol{i = 1, 2, \ldots..8}$

$$S = \begin{matrix} \sigma1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \sigma2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \sigma3 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \sigma4 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \sigma5 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \sigma6 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \sigma7 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \sigma8 \end{matrix}$$

And if values of $\boldsymbol{\sigma_i}$ again put into equation (20) we obtain x1, x2, x3, x4, x5, x6 x7 and x8 value

$$(W1 - \sigma_i I)x = 0 \qquad (20)$$

$$U = \begin{matrix} x1 & -x2 & -x3 & -x4 & -x5 & -x6 & -x7 & -x8 \\ x8 & x1 & -x2 & -x3 & -x4 & -x5 & -x6 & -x7 \\ x7 & x8 & x1 & -x2 & -x3 & -x4 & -x5 & -x6 \\ x6 & x7 & x8 & x1 & -x2 & -x3 & -x4 & -x5 \\ x5 & x6 & x7 & x8 & x1 & -x2 & -x3 & -x4 \\ x4 & x5 & x6 & x7 & x8 & x1 & -x2 & -x3 \\ x3 & x4 & x5 & x6 & x7 & x8 & x1 & -x2 \\ x2 & x3 & x4 & x5 & x6 & x7 & x8 & x1 \end{matrix}$$

And if

$$W2 = B1^T xB1$$
$$(W2 - \sigma_i I)x = 0 \qquad \mathbf{(21)}$$

And if values of $\boldsymbol{\sigma_i}$ again put into equation (21) we obtain x1, x2, x3, x4, x5, x6 x7 and x8 value

$$\boldsymbol{V} = \begin{matrix} x1 & x2 & x3 & x4 & x5 & x6 & x7 & x8 \\ -x8 & x1 & x2 & x3 & x4 & x5 & x6 & x7 \\ -x7 & -x8 & x1 & x2 & x3 & x4 & x5 & x6 \\ -x6 & -x7 & -x8 & x1 & x2 & x3 & x4 & x5 \\ -x5 & -x6 & -x7 & -x8 & x1 & x2 & x3 & x4 \\ -x4 & -x5 & -x6 & -x7 & -x8 & x1 & x2 & x3 \\ -x3 & -x4 & -x5 & -x6 & -x7 & -x8 & x1 & x2 \\ -x2 & -x3 & -x4 & -x5 & -x6 & -x7 & -x8 & x1 \end{matrix}$$

U, S and V computed for each 8x8 block of all level three DWT decomposed $\boldsymbol{x(n)_{LL2}}$, $\boldsymbol{x(n)_{LH2}}$, $\boldsymbol{x(n)_{L22}}$ ***and*** $\boldsymbol{x(n)_{HH2}}$, As explain above.

$$U_{x(n)_{LL2}}, S_{x(n)_{LL2}}, V_{x(n)_{LL2}} = SVD(x(n)_{LL2}) \qquad (22)$$
$$U_{x(n)_{LH}}, S_{x(n)_{LH2}}, V_{x(n)_{LH}} = SVD(x(n)_{LH2}) \qquad (23)$$
$$U_{x(n)_{HL2}}, S_{x(n)_{HL2}}, V_{x(n)_{HL2}} = SVD(x(n)_{HL2}) \qquad (24)$$
$$U_{x(n)_{HH2}}, S_{x(n)_{HH2}}, V_{x(n)_{HH2}} = SVD(x(n)_{HH2}) \qquad (25)$$

On the other hand W is the watermark image of PxQ size will logical XOR with the 8 bit key 'K'
W1= (W xor K) (26)
The Torus Automorphism disarranges the watermark bits equally and randomly before embedding and reconstructing it after extraction. Torus Automorphism is one of the kinds of a dynamic system. A dynamic system, changes the stats s when time t changes. Where p is a user input, it basically swap the pixel positions.

$$(x_{i+t,j+t}) \leftrightarrow x_{i,j} where\ t = \sqrt{p^2 - i^2} \qquad (27)$$

W2=torus(W1) with p=2
W3=torus(W2) with p=4
W4=torus(W3) with p=8
W5=torus(W4) with p=16
W6=torus(W5) with p=32

This is how scrambling done on watermark image W1 and W6 is developed after five time Torus Automorphism. Each samples of W6 converted into binary and an binary sequence generated

BW6=dec2bin(W6,8) *(28)*

Now BW6 is the watermark which is need to be hide inside the DWT and SVD decamped cover images which are shown in equations (22), (23), (24) and (25)

$$MS_{x(n)_{LL2}} = lsb(S_{x(n)_{LL2}})xor\ BW_i \quad (29)$$

$$MS_{x(n)_{LH2}} = lsb(S_{x(n)_{LH2}})xor\ BW_{i+1} \quad (30)$$

$$MS_{x(n)_{HL2}} = lsb(S_{x(n)_{HL2}})xor\ BW_{i+2} \quad (31)$$

$$MS_{x(n)_{HH}} = lsb(S_{x(n)_{HH2}})xor\ BW_{i+3} \quad (32)$$

Equation (29), (30), (31) and (32) develop modified S components of SVD

$$(x(n)_{NLL2}) = U_{x(n)_{LL2}} * MS_{x(n)_{LL2}} * V_{x(n)_{LL2}}{}^T$$

$$(x(n)_{NLH2}) = U_{x(n)_{LH2}} * MS_{x(n)_{LH2}} * V_{x(n)_{LH2}}{}^T$$

$$(x(n)_{NHL2}) = U_{x(n)_{HL2}} * MS_{x(n)_{HL2}} * V_{x(n)_{HL2}}{}^T$$

$$(x(n)_{NHH2}) = U_{x(n)_{HH2}} * MS_{x(n)_{HH2}} * V_{x(n)_{HH2}}{}^T$$

IDWT 3rd level

$$x(n)_{NHH1L} = \sum_{n=-\infty}^{\infty} \{x\left(\frac{n}{2}\right)_{NLL2} \pm x\left(\frac{n}{2}\right)_{NLH2}\}$$

$$x(n)_{NHH1H} = \sum_{n=-\infty}^{\infty} \{x\left(\frac{n}{2}\right)_{NHL2} \pm x\left(\frac{n}{2}\right)_{NHH2}\}$$

$$x(n)_{NHH1} = \sum_{n=-\infty}^{\infty} \{x\left(\frac{n}{2}\right)_{NHH1N} \pm x\left(\frac{n}{2}\right)_{NHH1H}\}$$

$$x(n)_{NHHH} = \sum_{n=-\infty}^{\infty} \{x\left(\frac{n}{2}\right)_{NHH1} \pm x\left(\frac{n}{2}\right)_{HL1}\}$$

$$x(n)_{HHL} = \sum_{n=-\infty}^{\infty} \{x\left(\frac{n}{2}\right)_{LL1} \pm x\left(\frac{n}{2}\right)_{LH}\}$$

$$x(n)_{NHH} = \sum_{n=-\infty}^{\infty} \{x\left(\frac{n}{2}\right)_{NHHH} \pm x\left(\frac{n}{2}\right)_{HHL}\}$$

$$x(n)_{NH} = \sum_{n=-\infty}^{\infty} \{x\left(\frac{n}{2}\right)_{NHH} \pm x\left(\frac{n}{2}\right)_{HL}\}$$

$$x(n)_{L} = \sum_{n=-\infty}^{\infty} \{x\left(\frac{n}{2}\right)_{LL} \pm x\left(\frac{n}{2}\right)_{LH}\}$$

$$x(n)_{N} = \sum_{n=-\infty}^{\infty} \{x\left(\frac{n}{2}\right)_{L} \pm x\left(\frac{n}{2}\right)_{NH}\}$$

$\boldsymbol{x(n)_N}$ is the final cipher image which will have watermark image hidden inside it.

The deciphering is process for as can be observed it exact reverse order than the ciphering process and our aim is to extract watermark not construct the original image so we did the process to have original data only.

III-RESULTS

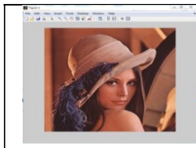		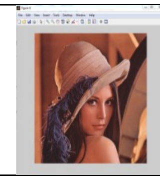
Cover image	Watermark image	Cipher image

Figure 5 Selected cover image (1) and watermark images(2) and cipher image developed (3)

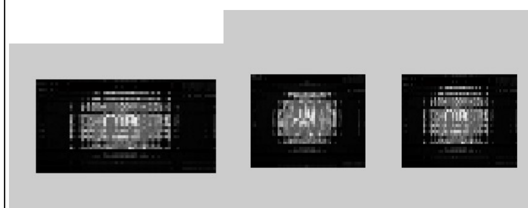

Figure 6 watermark image torus Automorphism level

If Where D is cipher image, C is cover image, len is length of cover image then

MSE= (D – C)^2/ Len, SNR= 10 log 10 (256^2/MSE), BER = sum of (Data xor Cipher) / (Len x 8)

Observe Results test cover image of Lena (512x512, 712 kb) and the cover images of 60x60 (4kb), 95x95 (8kb) and 128x128 (12 kb)

Cover Size	**Watermark size**	**SNR**	**MSE**	**BER**
512x512/ 712kb	60x60/4kb	80.57	0.27	0.2444
512x512/ 712kb	95x95/8kb	70.99	1.20	0.78
512x512/712 kb	128x128/12 kb	68.97	1.63	0.84

Table 1 observe results for cover Lena image with different size watermark image

COMPARATIVE RESULTS: The comparative results are comparison between proposed method watermarking with available method of watermarking and it can be done on the behalf of SNR observe by the different methods for the standard cover image of 512x152 and watermark of 128x128 size.

Sr. NO.	**AUTHOR**	**Output**

1.	Po-Yueh Chen et al	46.74dB
2.	Tanmay Bhattacharya et	27.3850
3.	Archana S. Vaidya et al	29.64
4.	Hyung -Shin Kim et al	36 dB
5.	Mayank Awasthi et al	49.91
6.	Nallagarla.Ramamurthy	51.8 dB
7.	G. Rosline Nesa	49.48
8.	Krishna Rao Kakkirala	52.56
9.	Aniket Roy et al	51.9541
10	Amra siddiqui et al	PSNR
11	Zhi Zhang et al	PSNR
12	Proposed work	PSNR

Table 2 Comparative result

From the comparative results above we can clearly observe that the proposed work has best SNR among all available work.

IV-CONCLUSION

Watermarking is a way to deal with shroud the information (picture for our situation) productively into any covering object (picture for our situation) and it ought to do that any gatecrasher can't translate it by any methods, it can be finished up based on writing work that accessible strategies are great in watermarking yet there are still a few issues with those procedures and that can be make strides. . It can be inferred that DWT is the most appropriate technique for versatile watermarking and SVD is the strategy which most appropriate for lossless and assault free correspondence.

The first target of the proposal work was to build up an enhanced system for concealing picture and information inside cover picture additionally to diminish the measure of information on channel while stenograph information transmission which is been accomplished. The issue with watermarking is that it requires heaps of information implies another greater picture for sending some little watermark picture, proposed work accomplished that same size of watermark can be transmitted with little size of cover picture as accomplished SNR is superior to accessible work 69.4.

REFERENCES

[1] Zhi Zhang, Chengyou Wang, Xiao Zhou, Image Watermarking Scheme Based on Arnold Transform and DWT-DCT-SVD, ICSP2016, 978-1-5090-1345-6/16/2016 IEEE

[2] Amra Siddiqui, Arashdeep Kaur, A protected and powerful picture watermarking framework utilizing wavelet space, 2017 seventh International Conference on Cloud Computing, Data Science and Engineering - Confluence, IEEE, DOI: 10.1109/CONFLUENCE.2017.7943222

[3] Aniket Roy, Arpan Kumar Maiti, Kuntal Ghosh, A discernment based shading picture versatile watermarking plan in YCbCr space, 2015 second International Conference on Signal Processing and Integrated Networks (SPIN), 978-1-4799-5991-4/15/2015 IEEE

[4] Krishna Rao Kakkirala, Srinivasa Rao Chalamala, Block Based Robust Blind Image Watermarking Using Discrete Wavelet Transform, 2014 IEEE tenth International Colloquium on Signal Processing and its Applications (CSPA2014), 7 - 9 Mac. 2014, Kuala Lumpur, Malaysia

[5] G.Rosline Nesa Kumari, Dr.S.Maruthuperumal, Dr.V.Vijayakumar, Hierarchical-Edge based Torus Automorphism for Digital Watermarking, International Journal of Science, Engineering and Technology Research (IJSETR) Volume 2, Issue 2, February 2013

[6] Nallagarla.Ramamurthy, Dr.S.Varadarajan, Effect of Various Attacks on Watermarked Images, (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 3 (2) , 2012,3582-3587