Dynamic scaling with R-DWT and Differential Evolution for Robust Color Digital Image Watermarking

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ABSTRACT- *Watermarking is technique of inserting secret information on digital image enabling ownership, identity, Copyright protection. The main properties of a good image watermarking are imperceptibility, robustness and security. Image Processing is a field that continues to grow, with new applications being developed at an ever increasing rate. In this paper we work on color digital image watermarking and image split in three channels (Red, Green, and Blue). In this paper, proposed scheme are R-DWT and Differential Evolution (DE) with use of optimal scaling. First of all , we comparison between R-DWT and DWT , which execute best value for PSNR and Correlation Coefficient and Secondly ,use optimal scaling on DE algorithm execute with help of R-DWT. The PSNR and CC as fitness function in DE and obtain the robustness and imperceptibility of watermarking system. Experimental results indicate that Differential evaluation (DE) use of dynamic scaling on host image and watermark image and make best value of Correlation coefficient (CC).*

Key word **- Watermarking, SVD, R- DWT, DE, PSNR, CC.**

1. INTRODUCTION

Owning to the hasty growth of computer network and Internet, anybody can switch of digital information quick and easily use of multimedia data. Therefore, such applications have also raised anxiety about illegal variation and copyright issues. Digital image watermarking from now proves to be a significant tool to maintain intellectual property rights. Watermarking is a procedure of inserting information into component such as an image, audio and video file. The notion after image watermarking is to hide surreptitious information contained by an image without noticeably changing the host. Watermarking applications in the fields of copyright protection, ownership identification, tamper detection, broadcast monitoring, different medical applications as well as secret communications etc. The fundamental necessities related to any watermarking structure are robustness, imperceptibility and protection. The embedding information can later be extracted from multimedia for organize the copyright owner.

In this watermarking need to execute two main steps i.e. coding and decoding. In watermarking procedure, which contain embedding information into a multimedia element can be executing in spatial domain, frequency domain and hybrid domain. Least Significant Bit (LSB) method is used in spatial domain. The frequency domain watermarking is generally used as it is robust to compression schemes and direct watermark in embedding of compacted bit stream. The transform (frequency) domain method include DWT(Discrete Wavelet Transform),SWT(stationary wavelet transform) ,DFT(Discrete Fourier Transform), DCT (Discrete Cosine Transform) and SVD (Singular Value Decomposition) . Even though transform-domain schemes can defer more information embedding and more robustness against many general attacks, the computational cost is superior to spatial-domain watermarking techniques.

2. LITERATURE REVIEW

Tulikan bhuyan, et al, 2016 [1] The SVD used in this scheme is a variant of the traditional SVD and is shuffled SVD (SSVD). PSNR value above 30db and correlation coefficient values close to 1 are obtained using scaling factor 0.4. R. Surya Prakasa Rao et al, 2016 [2] The Genetic Algorithm optimization(GA) is used for best scaling factor (SF) to modify the SVD coefficients of watermark image .in this simulation various test are done on original image. Xiao-Long Liu, et al, 2016 [3] The invisible, fragile and robust watermarks are embedded into the spatial domain of the RGB colour space and into the frequency domain of YCbcr colour space. Asit Kumar Subudhi, et al, 2015[4] Article signify the addition of color image watermarking from grey scale image watermarking using DHT and DCT and distinction between both. Preeti Sharma, et al, 2015[5] in this article using contourlet transform for colored digital images watermarking. Priyanka, et al, 2015 [6] Author represents DCT based Blind digital watermarking technique for still color images. Anu Bajaj, 2014 [7] The paper signify hybrid image watermarking technique which takes advantage of different transforms like RDWT, DCT, SVD and trigonometric functions. Preeti Sharma, et al, 2014 [8] In this article hybrid watermarking scheme using SVD and DWT has been introduced, where the watermarked 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 mechanism to give up the watermarked image. Muhammad Imran, et al, 2012 [9] A non-blind color image watermarking method using standard component analysis, discrete wavelet transform and singular value decomposition is planned. Nagaraj V. Dharwadkar, et al, 2011[10] this scheme embeds the watermark into cover image in RGB space. The combinations of Discrete Wavelet Transformation (DWT) and Singular Value Decomposition (SVD) of Blue channel are used to embed the watermark.

3. REVIEW OF BACKEND

3.1 REDUNDANT DISCRETE WAVELET TRANSFORM (R-DWT)

Discrete wavelet transform (DWT) is one of the current wavelet transforms used in image processing. Discrete wavelet transform method for image resolution improvement is interruption, but the major loss of is high frequency apparatus in image decompose an image into various sub- band images that is LL,LH,HL,HH. An additional current wavelet transform which has been used in a number of image processing applications is redundant discrete wavelet transform (R-DWT). In short, R-DWT is related to DWT however it does not use down-sampling, thus the sub-bands will have the equal size as the input image. DWT is not a time-invariant transform. The R-DWT is defined as repair of translation invariance to slightly varied DWT called un-decimated DWT. This can be done by step of down-sampling the decimated technique and for up-sampling be appropriate filters by adding zeros between the filter coefficients. Technique in which the filter is upsampled is called "à trous", meaning "with holes".

3.2 SINGULAR VALUES DECOMPOSITION (SVD)

Singular values decomposition (SVD) acquires a rectangular matrix of phrase data defined as A, where $A = n \times k$ matrix in which n rows and k columns. Singular value decomposition is linear algebraic formula which access on mathematical problems. The SVD related to orthogonal transform which decompose the matrix into three matrices of same size. The SVD rule is:

$$A = U \times S \times V^T$$

Where the columns of U are the left singular vector, S is singular values i.e. diagonal and V^T has rows that are right singular vectors. Singular value decomposition (SVD) applies on image that split in to $u \times s \times v$ matrix form that extracts singular value. We are applying SVD on HL sub-band of host image and L HL band of watermark image that decay the image into W_u, W_s and W_v.

3.3 COST MEASAURE

3.3.1 Mean Square Error (MSE)

MSE in watermarking is to measures the average of square of errors between original image and watermark image.
It is given by:

$$MSE = \frac{1}{M \times N} \sum_i \sum_j [I(i,j) - I_w(i,j)]^2 \quad \text{(E.q. no......... 1)}$$

Where M, N is pixel values in host image
$I(i,j)$= Pixel value of original Image
$I_w(i,j)$=Pixel value of watermark Image

3.3.2 Peak signal to noise ratio (PSNR)

PSNR determines the Efficiency of Watermarking with respect to the noise.
It is given by:

$$PSNR = 10 * log\left(\frac{255}{\sqrt{MSE}}\right) \quad \text{(E.q. no...... 2)}$$

3.3.3 Correlation Coefficient (CC)

To evaluate the correlation coefficient between the embedded and the extracted watermark. Now W is the embedded and W^* extracted watermark. μ_w is the mean cost Of embedded extracted watermark and μ_w^* is the mean cost of extracted watermark. The cost of CC lies between 0 and 1.
It is given by:

$$\rho(W, W^*) = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N}(w_{ij}-\mu_w)(w^*ij-\mu^*w)}{\sqrt{\sum_{i=1}^{N}\sum_{j=1}^{N}(w_{ij}-\mu_w)^2}\sqrt{\sum_{i=1}^{N}\sum_{j=1}^{N}(w^*ij-\mu_w^*)^2}}$$

(E.q no.........3)

4 COLOR IMAGE WATERMARKING SCHEME

4.1 Algorithm for Embedding Approach

Step1: Read both original image and watermark image. Firstly, original image split into 3 channels (Red, Blue, and Green).
Step2: Apply R-DWT to decompose the input image into four sub-bands (i.e. LL, LH, HL, and HH). Use the three channels (Red, Blue, and Green) on HL sub-band.
Step3: Apply SVD to HL sub-band that split the image into *I_u, I_s* and ***I_v*** matrix form that extract the singular values. Where s = scaling matrix.
[I_u, I_s, I_v] = svd (HL)
Step4: Apply R-DWT on the watermark image and split image into four sub-bands. Use the three channels on WHL sub-band.
Step5: Apply SVD on WHL sub-band that split image into W_u, W_s, W_v matrix form extract singular values.
[W_u, W_s, W_v] = svd (WHL)
Step6: Use of optimal scale matrix, which gives finest values and stores in alpha variable.
alpha = get optimal _scale_matrix (scaleMatrixDim);
Step7: Use this formula for watermarked image and apply on all channels (Red, Blue, and Green).
S_n = I_s + (α*W_s);
Step8: The watermarked image is obtained by performing inverse SVD and R-DWT.
Step9: Compute the PSNR value for input original image and watermarked image using formula (Eq. no....2).

4.2 Algorithm for Extraction Approach

Step1: Apply R-DWT to decompose the watermarked image into four sub bands (i.e. LL, LH, HL, and HH).
Step2: Choose WMHL sub-band and transformed in 3 color channels R, B and G.
Step3: Apply SVD to WMHL sub-band to extract the singular values.
[Wm_u, Wm_s, Wm_v] = svd (WMHL) **Step4:** Apply R-DWT on original image to decompose image into four sub bands (i.e. LL, LH, and HH).
Step5: Apply SVD to HL sub-band that split the image into *I_u, I_s* and ***I_v*** matrix form that extract the singular values. Where s = scaling matrix.
Step6: Compute Sw use of this formula, where Sw is the singular matrix of extracted image.
S_w = (Wm_s-I_s) /α;
Step7: Apply R-DWT on watermark image to decompose into sub-bands (i.e.WLL, WLH, WHL, WHH).
Step8: Obtain the extracted watermark image by performing inverse SVD and R-DWT.
Step9: check out the correlation coefficient of watermarked image and extracted watermark image that will be noiseless.CC in Eq. no…3.

4.3 DYNAMIC SCALING

Dynamic Scaling helps for providing the better values. In Dynamic Scaling, we used two most important factors:

4.3.1 Differential Evolution

Differential evolution (DE) is a technique that optimizes a crisis by repetitively tries to get well a candidate solution with hold to a set measure of value. The basic technique of DE work on a population of candidate solution it's called agents. These agents are travel around in search-space by using mathematical rule to combine the site of exiting agents from the population. If latest position of an agent is an improvement it is accepted and forms element of the population, otherwise the new position is basically unnecessary. The procedure is repeated again and so it is hoped, but not assured, that a suitable solution will finally be discovered.

Properly, let *F*: $K^n \rightarrow K$ be the cost function which should5 be minimized or fitness function which should be maximized. The task takes a candidate result as argument in the form of a vector of real numbers and generates a real no. as output which specifies the fitness of the given candidate result. The gradient of *F* is unknown. The aim is to find a result *m* for which *m* is the overall minimum. Maximization can be executed by considering the function $h := -f$as a substitute. Let $y \in K^n$ assign a candidate solution in population. $CR \in [0,1]$ is called the crossover probability. Let F$\in [0,2]$ be called the differential weight. These parameters are select by the practitioner along with the population size NP ≥ 4.

DE method explains below follow as:
Step1: Set the all agents Y with random position in the search-space.
Step2: Until an execution criterion is met (e.g. no. of iterations performed), do again the following:
Step3: For each agent Y in population do:
Step4: select three agents a, b and c from the population at random, they should be different from each other as well as from agent Y.
Step5: Select a random key K $\in \{1, \ldots, n\}$(*n* being the dimensionality of the problem to be optimized).
Step6: calculate the agent's possible new position X= $[x_1, \ldots . x_n]$ as follows:
Step7: For each I $\in \{1, \ldots n\}$ select an evenly distributed number$r_i \equiv U(0,1)$.
Step8: If $r_i < CR$ or I=K then set otherwise set $x_i = y_i$ (the new site is the outcome of the binary crossover of agent Y with the intermediate agent$z = a + F \times (b - c)$.
Step9: If $f(x) < f(y)$ then replace the agent in the population with the improved candidate solution, i.e. change y within x the population.
Step10: Select the agent from the population that has the highest fitness or lowest cost and return it as the finest found candidate solution.

4.3.2 Fitness Function:

In this paper, Correlation coefficient uses as fitness function. When we enhance the value of correlation coefficient increases the fitness function. So, optimization of the reliability takes place for the given value of robustness. We used Correlation Coefficient (CC) on various attacks. In this paper, we apply correlation coefficient on host image and watermarked image as fitness function. We get better quality of image with help of correlation coefficient.

5 EXPERTIMENTAL RESULT

In this experiment result we discuss about two improvement in proposed scheme first is Redundant Discrete Wavelet Transform (R-DWT) perform better than Discrete Wavelet Transform (DWT) which increase peak signal to noise (PSNR) values and correlation coefficient(CC). Second is use of optimal scaling on Differential Evaluation algorithm (DE).

5.1 Dynamic Scaling with R-DWT

The succession of experiment is accomplished to analyze the effect of embedding and extraction algorithm on color image. The experiment on proposed work the input image and watermark image of size 512×512 are considered.

Fig (5.1) and fig (5.2) shows the series of output of embedding and extraction algorithms.

Input image Watermark Watermarked

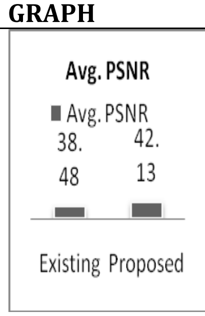
Fig. -5.1: Output of Embedding Algorithm

Watermarked image Extracted image

Fig.-5.2: Output of Extracted Algorithm

In this paper, we show comparison between Exiting work which use the discrete wavelet transform (DWT) and proposed work which use the R-DWT. The experiment results show that R-DWT perform better than DWT. We can see that fitness function PSNR increase 3.6 more than exiting work. We can see in Table -.5.1, this overall procedure apply in embedding process.

Table – 5.1: show PSNR approach and Graph of Avg. of PSNR

PSNR APPROCH			GRAPH
Channels	Existing	Proposed	
Red	38.1387	42.06113	
Green	38.1712	41.81356	
Blue	39.1449	42.52121	
Avg. Of PSNR	38.485	42.132	

In extraction algorithm we apply various attacks i.e. Average filtering (AF), Rescaling (RS), Gamma Correction (GC), Gaussian noise (GN), JPEG compression, Gaussian lowpas filtering (GF), sharpening (SH), Contrast adjustment (CA). Comparison between existing scheme and proposed scheme. The experiment results show in Table-5.2 give values of correlation coefficient between existing scheme and proposed scheme.

Table-5.2Comparison between Existing and Proposed Approch

ATTACKS	*Avg. NC Exiting Work*	*Avg.NC Proposed Work*
Average Filtering	 **0.988666**	 **0.993**
Rescaling	 **0.9863333**	 **0.991**
Gamma Correction	 **0.9706666**	 **0.9913333**
Gaussian Noise	 **0.971**	 **0.9886666**
JPEG Compression	 **0.9883333**	 **0.998333**
Gaussian Lowpass fil.	 **0.9846666**	 **0.999**
Sharpening	 **0.99833333**	 **0.948**
Contrast Adjustment	 **0.977333333**	 **0.9233333**

5.2 Dynamic Scaling with Differential Evolution (DE)

The watermark embedding process and iteration graph has been shown in fig.-5.3 and Chart-1. Algorithm for watermarking embedding use Lena image as input (256*256) and watermark Image of size (128* 128). The experimental result show that dynamic scaling implement better than static scaling .we can see in Chart-1 of iteration which execute total 20 iteration. We obtain best value of iteration at 20th level of iteration that is 0.999991546.

Input image **Watermark** **Watermarked**

Fig.-5.3: Embedding process with DE algorithm

In Chart-1, the plotted graph is between fitness function correlation coefficient and iteration. In graph show iteration the X_axis whereas, fitness value on the y_axis. Main notion of this paper is fitness funcation and Dynamic Scaling. Optimization algorithm has objective function which should forever maximize to get larger Correlation Coefficient (CC) values. The correlation coefficient fitness function applies on host image and watermark image. In experiment optimal scaling use DE algorithm. DE technique worked on the population of candidate solution (called agents). Use of DE algorithm with optimal scaling we obtained better result to simple optimization with R-DWT. We can see in Table- 5.3 PSNR value is better in embedding process.

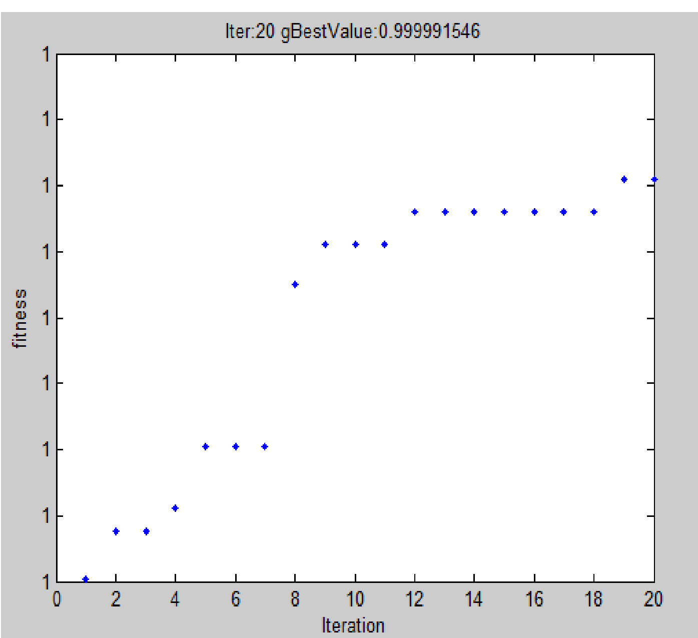


Chart-1 Iteration graph at running time

Table -5.3: PSNR value and Iteration

Channels	PSNR Value
Red	86.518367
Green	82.871376
Blue	83.508067
Avg. PSNR	84.033902
Iteration best value	0.999991546

6 Conclusion

In this paper, proposed a new watermarking scheme has been using a Dynamic scaling factor. We are proposed scheme Redundant Discrete Wavelet Transform (R-DWT) and differential evaluation (DE) with use of optimal scaling. In previous work , we are see use of DWT and static scaling factor but in our proposed approach use of R-DWT and optimal scaling , which give better result to exiting approach . We are use of differential evaluation with optimal scaling which give better result to R-DWT. This study also shows good robustness against various attacks with Correlation Coefficient (CC). In this paper, PSNR value amplifies 3.6 with use of R-DWT and best value is 0.9999915 in iteration. Correlation Coefficient (cc) use as fitness functions in dynamic scaling with DE algorithm. In future we can use different type algorithm with optimal scaling and improve in both PSNR, Correlation coefficient (cc) and we can apply various new attacks.

Reference

[1] Tulikan bhuyan, vinay kumar srivastava and falgun thakkar "Shuffled SVD based Robust and Secure Digital Image Watermarking" International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT) – 2016, 978-1-4673-9939-5/16/$31.00 ©2016 IEEE

[2] R. Surya Prakasa Rao and Dr. P. Rajesh Ku "An Efficient Genetic Algorithm Based Gray scale Digital Image watermarking for Improving the Robustness and Imperceptibility" IEEE International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT) 978-1-4673-9939-5/16,IEEE.

[3] Xiao-Long Liu, Chia-Chen Lin*, Member, IEEE, and Shyan-Ming Yuan "Blind dual watermarking for color images' authentication and copyright protection" 1051-8215 (c) 2016 IEEE.

[5] Preeti Sharma and Pallvi Chawla *"Robust Digital Watermarking using Contourlet Transform for Coloured Images"* 2015 Third International Conference on Image Infonnation Processing, 978-1-5090-0148-4/15/$31.00© 2015 IEEE

[6] Priyanka, et al, *"An Efficient DCT based Image Watermarking Using RGB Color Space "* 2015 IEEE 2nd International Conference on Recent Trends in Information Systems (ReTIS), 978-1-4799-8349-0/15/$31.00 ©2015 IEEE.

[7] Anu Bajaj "Robust And Reversible Digital Image Watermarking Technique Based On RDWT-DCT-SVD" IEEE International Conference on Advances in Engineering & Technology Research (ICAETR - 2014), August 01-02, 2014, Dr. Virendra Swarup Group of Institutions, Unnao, India.
[8] Preeti Sharma and Tapan Jain" Robust Digital Watermarking for Coloured Images using SVD and DWT Technique" 2014 IEEE International Advance Computing Conference (IACC) 978-1-4799-2572-8/14,IEEE.
[9] Muhammad Imran, Abdul Ghafoor, Muhammad Rizwan Khokher "A Robust Non-blind Color Image Watermarking Scheme" 2012 12th International Conference on Control, Automation, Robotics & Vision Guangzhou, China, 5-7th December 2012 (ICARCV 2012), 978-1-4673-1872-3/12/$31.00 ©2012 IEEE.
[10] Nagaraj V. Dharwadkar, B. B. Amberker & Avijeet Gorai "Non-blind Watermarking scheme for color images in RGB space using DWT-SVD" , 978-1- 42 4 4-9799-7/11/$26.00 ©20 11 IEEE.