International Journal of Advanced Technology in Engineering and Science
Vol. No.3, Issue 09, September 2015
www.ijates.com
ijates
ISSN 2348 - 7550

DE AND PSO BASED HYBRID OPTIMIZED WATERMARKING SYSTEM FOR COPYRIGHT PROTECTION AND AUTHENTICATION

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ABSTRACT

Digital contents are simply broaden over through the continually growing communication media like Internet. Image watermarking has become a significant tool for intellectual copyright protection and authentication. In this paper a novel hybrid optimized watermarking system is designed with help of Discrete Wavelet Transform, DE and PSO which tender the solution to the issues such as Copyright Protection and authentication. The coefficients are selected in Discrete Wavelet Transform with help of DE and PSO to embed the DCT transformed selected high energy coefficients watermark bits in the host image. The image quality index metric (IQIM) is used to measure the image quality distortion. The experimental results are assessed with respect to IQIM, PSNR and BCR and offered to exhibit the capability of the proposed system.

Keywords: DCT, DE, DWT, PSO and Watermarking.

I. INTRODUCTION

In the modern world, the internet and information communication technology have grown-up drastically which gives a platform to produce, re-produce, edit, tamper and store multimedia contents effortlessly. Hence the security of the intellectual property rights, authentication and confidentiality of digital images becomes a significant issue. Watermark is an owner designed logo, image, digital sign or trademark which can be concealed in the owner's image products. Digital watermarking performs two major activities that is (i) Watermark embedding and (ii) Watermark extraction. The embedding process inserts the watermark in the host image in order to obtain the watermarked image and watermark extraction process extract the embedded watermark from the watermarked image. The digital watermarking technique embeds watermark information or logo in cover signals provided that the watermark does not affect the human perception on cover signal and the watermark can be noticed only using signal processing techniques [1], [2].

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ISSN 2348 - 7550

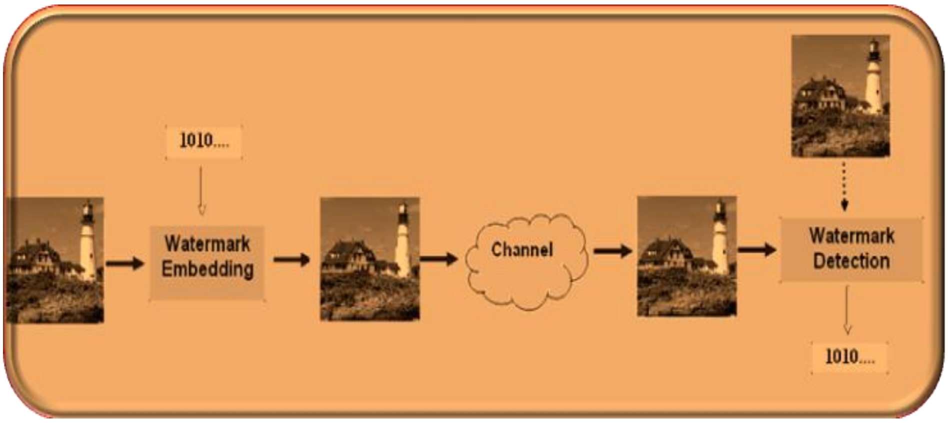

Fig.1. Common Image Watermarking System

Sinha.A. et al. have offered an image watermarking scheme, where the binary watermark is scrambled using 1-dimensional map before it is embedded. The watermark contains almost equal number of zeros and ones [3].Peter Wong H.W. et al. have suggested frequency domain image watermarking scheme using DCT and iterative watermark, wherein the multiple watermarks are embedded in the DCT domain using different keys and iterative watermarking technique. This scheme embeds watermarks into JPEG compressed images [4]. Kim.M. et al. have dealt content based fragile watermarking scheme for image authentication. This model having capability to tolerate incidental distortions and locate tampered regions. The embedding and extraction of content based watermark is performed through DCT transform [5].Habib.M. et al. have proposed frequency domain image watermarking scheme using DCT domain for ownership proof and identification. The information of the content owner is used to build the watermark for copyright protection [6]. Li,C.T. et al. have recommended a fragile watermarking scheme based on DWT domain which is capable resisting all kinds of manipulations and locating the tampered regions[7].

Bandyopadhyay et al. have offered the robust image watermarking scheme, where the polarity information is used to modify the middle frequency coefficients to accomplish robustness. This scheme provides high security against removal of watermark by the users or destroyed by JPEG compression [8].Ramana Reddy et al. have proposed the image watermarking scheme in which the watermark is embedded without affecting the quality of the image and while making it possible to extract the watermark by use of correlation based on HVS [9]. Ching-Yung Lin et al. have detailed the frequency domain image watermarking scheme using DCT coefficients to create digital signature. In this scheme, the invariance of the relationship between DCT coefficients is preserved when DCT coefficients are quantized in JPEG compression [10].Venkata Kishore.Ch. et al. offered that robust watermarking algorithm based on Human Visual System, Integer Discrete Cosine Transform and Particle Swarm Optimization. In this algorithm, the robustness and visibility are balanced by means of PSO and Human Visual System (HVS) [11].Chih-Chin Lai et al. have explores a new frequency domain optimized watermarking scheme using DCT and PSO. This scheme provides an effective solution to protect various kinds of digital contents against illegal use and variety of attacks [12].

Muhammad Ishtiaq et al., have suggested the image watermarking scheme, where the watermark strength is selected based on PSO. The DCT transform is exercised to modify the image coefficients and mid-band coefficients are selected for watermark embedding. This scheme yields better outputs in robustness and imperceptibility [13].Jia Mo et al. have recommended an innovative frequency domain optimized watermarking scheme using CT-SVD watermarking that includes the watermark preprocessing, the watermark embedding, and extraction. The contourlet transform is used to modify the host image to get the low frequency sub band images on which the SVD decomposition is then implemented before embedding the preprocessed watermark. The watermark extraction is the reverse of watermark embedding. Particle Swarm Optimization (PSO) is used to maximize the watermark robustness while maintaining its imperceptibility [14].Maulik Srivastava, Anuradha Sharma have proposed invisible Image Watermarking scheme that utilizes Least Significant Bit for embedding the secret information in the target image. The process has been achieved with help of MATLAB[15].

In this paper, a competent hybrid optimized image watermarking system is developed based on DWT transform, DE and PSO algorithms for copyright protection. The rest of this paper is organized as follows. Section 2 provides the information about method of differential evolution. In section 3, Particle Swarm Optimization technique is explained. The Section 4 offers Proposed Hybrid Optimized image watermarking method with Discrete Wavelet Transform(DWT), Differential Evolution(DE) and particle swarm optimization(PSO). The section 5 contains the formulae to measure the performance such as image quality index(IQIM), peak signal-to-noise ratio(PSNR) and correlation coefficient(BCR). The experimental results and security analysis are presented in Section 6 and Section 7 concludes this paper.

II. DIFFERENTIAL EVOLUTION

Differential Evolution(DE) is one of the most powerful stochastic real-parameter optimization algorithms. DE exhibits remarkable performance in optimizing a wide variety of multi-dimensional and multi-modal objective functions in terms of final accuracy, convergence speed, and robustness [16]. In 1996, Price and Storn took a severe effort to replace the classical crossover and mutation operators in GA by alternative operators, and subsequently came up with a suitable differential operator to handle the problem. They proposed a new algorithm based on this operator, and called it differential evolution (DE) [17]. DE optimizes a problem by maintaining a population of candidate solutions and creating new candidate solutions by combining existing ones according to its simple formulae, and then keeping whichever candidate solution has the best score or fitness on the optimization problem at hand. DE two main stages: crossover and mutation. The crossover procedure takes two selected vectors and combines them about a crossover point thereby creating two new vectors. The mutation procedure modifies a certain vector subject to a mutation function, introducing further changing into the original vectors [18], [19], [20].

III. PARTICLE SWARM OPTIMIZATION

In 1995, Eberhart and Kennedy have proposed an alternative solution to the complex non-linear optimization problem by imitating the collective behaviour of bird flocks, particles, the bodes method of Craig Reynolds and socio-cognition and called their brainchild the particle swarm optimization(PSO) [21], [22]. PSO is a multi-agent parallel search technique. Particles are conceptual entities, which fly through the multi-dimensional search space. At any particular instant, each particle has a position and a velocity. These particles fly through a search space and have two essential reasoning capabilities: their memory of their own best position and knowledge of the global best. The particles start at a random initial position and search for the minimum or maximum of a given objective function by moving through the search space. A particle swarm optimizer is a population-based stochastic optimization algorithm modelled after the simulation of the social behaviour of bird flocks [23], [24], [25].

In PSO algorithm, every solution of the optimization problem is regarded as a bird in the search space, which is called particle. Every particle has a velocity by which the direction and distance of the flying of the particle are determined, and a fitness that is decided by the optimized function. The movement of a particle depends only on its velocity and the location where good solutions have already been found by the particle itself or in neighbouring particles. When a particle's neighbourhood is defined as the whole swarm, the PSO is called the global version, otherwise it is called the local version. This modification can be represented by the concept of velocity. Velocity of each agent can be updated as per equation (1) in inertia weight approach (IWA) and every particle updates its position as per equation (2).

$$v_{k+1} = w * v_k + c_1 * r_1 * (p_k - x_k) + c_2 * r_2 * (g_k - x_k) \quad (1)$$

$$x_{k+1} = x_k + v_{k+1} \quad (2)$$

IV. PROPOSED HYBRID OPTIMIZED IMAGE WATERMARKING SCHEME USING DWT, DE AND PSO

In this proposed image invisible digital watermarking system, Discrete Wavelet Transform is utilized to modify the image data and Particle Swarm Optimization (PSO) is participated a significant role to choose the high energy coefficients in the Discrete Wavelet domain. Differential Evolution(DE) based 256 bit secret key is included for embedding watermark bits. The watermark logo is modified through DCT transform, among high energy watermark bits are selected for embedding in host image. Then, the watermark bits are embedded using the modulation method. The secret key is playing an essential role in embedding as well as extraction of watermark and makes complexity to unauthorized users to extract the embedded watermark in this system.The performance of the proposed watermarking scheme is measured by calculating the universal image quality index Q (IQIM), Peak Signal to Noise Ratio (PSNR) and correlation coefficient (BCR) between the original and the watermarked images according to equations (7),(8),(9) respectively as described in Section 5. The universal image quality index *Q* is determined with respect to three factors such as loss of correlation, luminance distortion, and contrast distortion.

The inertial factor of each particle is updated according to approaching degree between the fitness of itself and the optimal particle. A particle identifies its better fitness value by selecting a lesser inertial weight and a particle identifies its worse fitness value by selecting a larger inertial weight. The proposed algorithm using this policy to search in large range and the estimated location of the optimal solution is established rapidly and search in small range in the late iterations in order that the exact solution is found. The inertia weight is estimated using a random number(*rn)* in the algorithm in order to jump out from local optimum and a least inertial weight factor is used to prevent the premature convergence. The inertial factors of the particles are updated according to equation (3).

$$w_m = \frac{rn}{pm}\left|\frac{f_{cp} - f_{opc}}{f_{opc}}\right|, \; w = w_m \quad if \quad w_m > w_0 \, , w = w_0 \quad if \quad w_0 > w_m \quad (3)$$

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ISSN 2348 - 7550

where, rn -random number, pm -Parameter, f_{cp} -fitness of current particle, f_{opc} - optimal particle currently.

Fitness function *f(x)* for PSO training is given in equation (4).

$$\text{Fitness function} \quad f(x) = Q + PSNR + \frac{1}{n}\sum_{i=1}^{n} \lambda_i R_i \tag{4}$$

where, Q-Image Quality Index, PSNR- Peak Signal-to-Noise Ratio,R-resistance against attacks, and weighting factor λ is used to balance the imperceptibility and robustness of the embedded watermark.

4.1. PSO Algorithm

Step 1: Generate randomly the initial position and velocity of the particles within predefined ranges.

Step 2: At each iteration, the velocities of all particles are updated according to equation(1)where *w* will be gained according to equation (3).

Step 3: The positions of all particles are updated according to equation(2). After updating, x_k should be checked and limited to the allowed range.

Step 4: Update pbest and gbest when condition is met.

if f(p_k) > pbest, then pbest = p_k . (5)

if f(g_k) > gbest , then gbest = g_k .

where f(x) is the objective function to be optimized.

Step 5: The algorithm repeats steps 2 to 4 until certain terminating conditions are fulfilled, such as a pre-defined number of iterations.

The algorithm reports the values of gbest and f(gbest) as its solution.

4.2. Watermark Embedding Procedure

The watermark embedding procedure for DWT domain and PSO is as follows:

Step 1: Perform DWT on the host image to decompose it into four non-overlapping multi-resolution coefficient sets: LL_1, HL_1, LH_1 and HH_1.

Step 2: Perform DWT again on LL_1 coefficients sets to get four coefficient sets: LL_{12}, LH_{12}, HL_{12} and HH_{12}.

Step 3: Select high energy coefficients in DWT domain with help of DE and PSO for embedding watermark bits.

Step 4: Perform DCT on watermark logo. Select high energy coefficients among DCT transformed watermark bits.

Step 5: Generate two uncorrelated pseudorandom sequences by a key. One sequence is used to embed the watermark bit 0 (PN_0) and the other sequence is used to embed the watermark bit 1 (PN_1).

Step 6: Embed the two pseudorandom sequences, PN_0 and P N_1, with a gain factor λ in the the selected coefficient sets of the DWT transformed blocks of host image. Instead of embedding in all coefficients the selected high energy coefficients in DWT domain are embedded. If we donate X as the matrix of the high energy coefficient sets, then embedding is performed according to equation (6) .

$$X' = \begin{cases} X + \lambda * PN0 & \text{Watermark\_bit} = 0 \\ X + \lambda * PN1 & \text{Watermark\_bit} = 1 \end{cases} \tag{6}$$

Step 7: Perform inverse DWT on transformed image, including the modified coefficient sets, to produce the watermarked host image.

4.3. Watermark Extraction Procedure

The watermark extracting procedure is the reverse of watermark embedding procedure.

V. MEASURES OF PERFORMANCE

The performance of the proposed watermarking system is measured by means of image quality index metric (IQIM), peak signal-to-noise ratio (PSNR), correlation coefficient (BCR) which are described as follows:

5.1 Image Quality Index Metric (IQIM)

The image quality distortion is measured with help of universal image quality index (IQIM), which is mathematically described and proposed by Zhou Wang, Alan. C.Bovik. The image quality distortion is calculated via equation (7) with respect to three characteristics such as loss of correlation, luminance distortion, and contrast distortion. If two images *f* and *g* are considered as a matrices with *M* column and *N* rows containing pixel values *f*[*i*,*j*], *g*[*i*,*j*], respectively ($0 \geq i > M$, $0 \geq j > N$), the universal image quality index *Q* may be evaluated as a product of three components:

$$Q = \frac{\sigma_{fg}}{\sigma_f \sigma_g} * \frac{2\bar{f}\bar{g}}{(\bar{f})^2 + (\bar{g})^2} * \frac{2\sigma_f \sigma_g}{\sigma_f^2 + \sigma_g^2} \qquad (7)$$

5.2 Peak Signal-To-Noise Ratio (PSNR)

The quality of the watermarked image is measured by error induced between the watermarked and original images due to embedding of watermark and which is represented by Peak Signal-to-Noise Ratio (PSNR) according to equation (8).

$$MSE = \left[\frac{1}{M \times N} \sum_{i=1}^{M} \sum_{i=1}^{N} [X(i,j) - X'(i,j)]^2 \right] , \; PSNR = 10 \log_{10} \left[\frac{MAX^2}{MSE} \right] \qquad (8)$$

where X and X' are the original and the watermarked images respectively, with image size of ($M \times N$). The larger values of PSNR yields the better results in quality of watermarked images.

5.3 Correlation Coefficient (BCR)

BCR is a measure of the resistance of the watermark against attempts to tamper or degrade it with different types of digital signal processing attacks. The correlation between the embedded and extracted watermarks to be measured by using the Bit Correct Rate (BCR), according to Equation (9) to assess the robustness of the watermarking algorithm.

$$BCR = \left[1 - \frac{1}{Mw \times Nw} \sum_{i=1}^{Mw} \sum_{i=1}^{Nw} [W(i,j) \oplus W'(i,j)] \right] \qquad (9)$$

where W and W' are embedded and extracted watermarks respectively, with size of ($M_W \times N_W$) and $\oplus$ denotes the exclusive-or (XOR) operation. The larger value of BCR is gives the better result.

VI. EXPERIMENTAL RESULTS AND SECURITY ANALYSIS

The hybrid optimized watermarking system suggested in section 4 has been experimented with 50 different images and the observed results are presented in this section. The proposed watermarking system is designed with help of Discrete Wavelet Transform, DE and PSO which solves the issues such as Copyright Protection and authentication. The test images are of size (512 x 512) with pixel values in the range 0 - 255. One such standard cover image namely “Lighthouse” is shown in figure 2(a). Different watermark logos, all of size (128 x128) are used. One such watermark logo “GURUVE” image is shown in figure 2.(b) is used for watermarking. The watermarked house image with “GURUVE” logo is shown in figure 2(c). The 256 bit secret key is generated through DE and is utilized to select high energy coefficients with help of PSO to embed the watermark. PSO based Wavelet transformed selected coefficients have large energies so that the embedded watermarks tend to be robust against different kinds of attacks. Then two uncorrelated pseudorandom noise (PN) sequences are generated which represent the ‘0’ and ‘1’ bits of the watermark to be embedded. The PN sequences corresponding to the DCT transformed watermark bits are embedded into the transformed coefficients of the cover image using the embedding function given in equation (6).

With the intention of test the robustness of the watermark, various incidental distortions like JPEG compression, noise and filtering are applied to the watermarked images. For example, JPEG compression(10%) is applied to the Lighthouse image using the proposed DE-PSO scheme and the corresponding watermarked image and extracted watermark are shown in figure 2(d) and 2(e) respectively. Then the Gaussian noise 3% is added and the corresponding watermarked image and extracted watermark are shown in figure 2(f) and 2(g) respectively. Then uniform noise 5% is added to the watermarked “Lighthouse” image using the proposed PSO scheme and the corresponding watermarked image and extracted watermark are shown in figure 2(h) and 2(i) respectively. Next Salt and Pepper noise 10% is added to the watermarked “Lighthouse” image using the proposed PSO scheme and the corresponding watermarked image and extracted watermark are shown in figure 2(j) and 2(k) respectively.

In order to test the robustness of the watermark, the incidental distortion low pass filter with STD 10 is applied and the filtered image and extracted watermark are shown in Figure 2(l) and 2(m) respectively. Then Median filtering with a radius of 5 pixels is applied and the filtered image and extracted watermark are shown in figure 2(n) and 2(o) respectively. Next sharpening is applied and altered image and extracted watermark are shown in figure 2(p) and 2(q) respectively. Then Gamma Correction 3% is applied and the filtered image and extracted watermark are shown in figure 2(r) and 2(s) respectively.

Fig. 2(a)

Fig. 2(b)

Fig.2(c)

International Journal of Advanced Technology in Engineering and Science
Vol. No.3, Issue 09, September 2015
www.ijates.com
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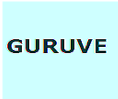
ISSN 2348 - 7550

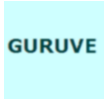
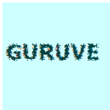



Fig.2(d) Fig.2(e) Fig.2(f) Fig.2(g)

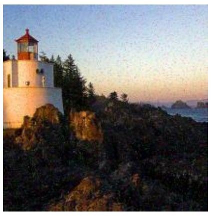
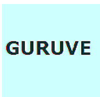



Fig.2(h) Fig.2(i) Fig.2(j) Fig.2(k)



Fig.2(l) Fig.2(m) Fig.2(n) Fig.2(o)

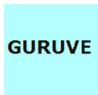



Fig.2(p) Fig.2(q) Fig.2(r) Fig.2(s)

Fig.2(a) Original Lighthouse Image, Fig.2(b) Watermark logo, Fig.2(c)Watermarked Lighthouse Image ,
Fig.2(d) JPEG compression with QF 10%, Fig.2(e) Watermark Extracted from Fig.2(d),
Fig.2(f) Gaussian noise 3%, Fig.2(g) Extracted Watermark from Fig.2(f),
Fig.2(h) Uniform noise 5%, Fig.2(i) Extracted Watermark from Fig.2(h),
Fig. 2(j) Salt and Pepper noise 10%, Fig.2(k) Extracted Watermark from Fig.2(j),
Fig.2(l) Lowpass Filter STD 10, Fig.2(m) Extracted Watermark from Fig.2(l),
Fig.2(n) Median filtering with a radius of 5 pixels, Fig.(o) Extracted watermark from Fig.2(n).
Fig.2(p) Sharpening , Fig.(q) Extracted watermark from Fig.2(p).
Fig.2 (r) Gamma Correction 3% , Fig.(s) Extracted watermark from Fig.2(r).
Fig. 2. Host Image, Watermark, Watermarked Image using the proposed DE-PSO system and Resultant Images with various Incidental Distortions and Extracted watermarks.

The performance of the proposed watermarking scheme is evaluated by calculating the IQIM and Peak Signal to Noise Ratio (PSNR) between the original and the watermarked images according to equations (7), (8) respectively. The correlation between the embedded and extracted watermarks is calculated via Bit Correct Rate (BCR) according to Equation (9) to assess the robustness of the watermarking algorithm and the observed results are included in Table 1. The same experiment is repeated on different test images and the observed results are included in Table 2 and the resultant images are given in Figure 3.

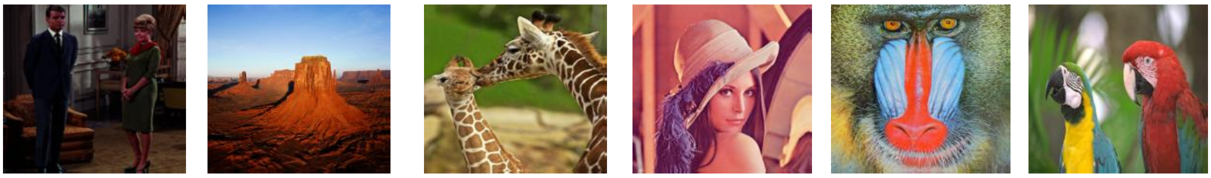


Fig. 3(a)Couple, Fig. 3(b)Desert, Fig. 3(c)Giraffe Fig. 3,(d) Lena, Fig. 3(e)Mandrill, Fig.3(f) Parrots Fig. 3. Watermarked Test Images using Proposed Scheme using DWM,DE,PSO

The histogram of original and watermarked test images are shown in Figure 4. However , histogram of watermarked images are somewhat differed from the histogram of related original host images due to embedded watermark bits.

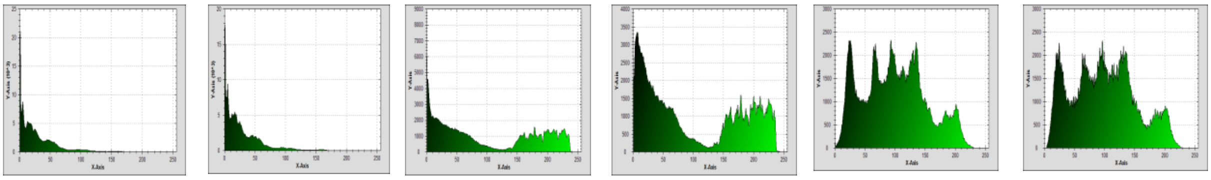


Fig.4(a) Histogram of Original Couple Image , 4(b) Histogram of Watermarked Couple Image shown in Fig.3(a), Fig.4(c) Histogram of Original Desert Image, Fig. 4(d) Histogram of Watermarked Desert Image shown in Fig.3(b), Fig.4(e) Histogram of Original Lena Image, Fig. (f) Histogram of Watermarked Lena Image shown in Fig.3(d)

Table1. Results after incidental distortions on Watermarked Light house image, Watermark logo: GURUVE

Incidental Distortions	Parameter	IQIM	PSNR	BCR
JPEG Comp	QF= 10	0.9972	62.2546	0.9841
Gaussian Noise	Noise= 3%	0.9917	57.2761	0.9912
Uniform Noise	Noise=5%	0.9856	49.2378	0.9848
Salt And Pepper	Noise=10%	0.9521	40.1276	0.9897
Low Pass Filter	STD Devi=10	0.9846	44.6598	0.9741
Median Filter	Radius of 5 pixels	0.9922	53.8972	0.9815
Sharpening	---	0.9763	44.6897	0.9896
Gamma Correction	Gamma Value= 3	0.9584	41.2145	0.9879

Table2. IQIM, PSNR, BCR values obtained from watermarked Test Images without Distortions using Proposed DWM System

Image	IQIM	PSNR	BCR
Couple	0.9871	66.4952	0.9912
Desert	0.9738	58.7821	0.9853
Giraffe	0.9764	57.7473	0.9822
Lena	0.9732	62.5786	0.9937
Mandrill	0.9606	50.7030	0.9754
Parrots	0.9857	70.6263	0.9849

The IQIMs of almost all the images are found to be minimum 0.9521 and the PSNRs of almost all the images are found to be minimum 40.1276dB denoting that the quality of the cover image is not much degraded. The

BCRs of almost all the images are found to be minimum 0.9741 which indicates the competence of the proposed DE-PSO based watermarking system.

VII. CONCLUSION

The hybrid optimized watermarking system is developed and presented with help of Discrete Wavelet Transform, Differential Evolution (DE) and Particle Swarm Optimization(PSO). The DE is utilised to generate secret key and PSO system is used to select the high energy coefficients for embedding watermark bits in the modified image via Wavelet Transform. The higher value of IQIM, PSNR and BCR results of experiments indicate that the proposed technique is better for image watermarking. The proposed hybrid optimized image watermarking system is successfully experimented and ensured for robustness to common image processing distortions.

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