

An optimal and secure watermarking system using SWT-SVD and PSO

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ABSTRACT

Digital Watermarking is the efficient way introduced to authenticate ownership of digital information. In a watermarking system, a logo is inserted to identify the ownership to digital information. The proposed system uses the SWT with SVD to embed the watermark image. To enhance robustness of the proposed system PSO is adapted for the selection of optimal coefficients. PSNR and CC are the two performance parameters considered to evaluate the system.

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1. INTRODUCTION

Today, internet is used worldwide for transfer of digital data, leading to number of issues for the ownership protection and for the digital resources [1]. In this Internet era we have more image processing tools to alter the visibility of the original images [1]. Digital watermarking method is used to overcome the unauthorized access of the data. Digital watermarking is a core application used in duplication, ownership identification, etc. Rapid growth in the technology and communication has made advancement in medical field for transmitting the information to/from the other hospitals [2]. The health centre and medical professionals use the wireless media in the globe. Transferring the medical data to/from one hospital to other will help in studying different medical cases and also helps in better medical result. Growth of using the internet and multimedia are on the rise, data access from the unauthorised persons has also increased, hence data hiding concept is introduced. The logo of the hospital is added to the patient data using the watermark technique. It will provide the security by restricting the unauthorized person from accessing the data. In the watermarking system there are two types visible and invisible watermarking. Assem [3] has presented an optimized performance for watermarking using meta-heuristic method. The aim of the optimization is to give good robustness with the minimum distortion. Hence when the optimization is used in watermarking, the system should be aware of quality of the image. The proposed optimization method does not require any weighting factor. Millie [4] proposed the fitness function in terms of scaling factor through Artificial Bee Colony (ABC) technique with Integer wavelet transform (IWT) and SVD (singular value decomposition). The proposed system is applied to number of fields of multimedia. Chang [5] has presented optimization study with single and multi channel perspective in RGB component. The conclusion from this

method is multichannel watermarking degrades the performance of the system. Baiying [6] has presented watermarking in an audio file. A new self adaptive PSO technique is used for optimization and Quaternion Wavelet Transformation (QWT). Self-adaptive particle swarm optimization (SPSO) method is used to obtain the optimal strength for the watermarking. Synchronization sequences are generated with the help of chaotic signals for de-synchronization attack. The chaotic signal improves the security of audio watermarking. Charu Agarwal et.al [7] has presented optimized watermarking system using DWT and SVD. The embedding method uses singular value of the watermark and host image by making use of multiple scaling factors (MSFs). Objective of the optimization is to find MSFs with Firefly Algorithm. PSNR is determined to verify the performance of the suggested system.

Mitashe et. al [8] has presented new approach with adaptivity in watermarking model by changing Fuzzy C-means clustering (FCM). DWT is used for inserting the watermark into the host image. Xie Beni integrated FCM is used to select the location in an image to insert. The key idea is to do efficient segmentation to an image to insert the watermark image so that the watermarked image can resist all type of image processing attacks. PSNR, MSE and CC parameters are determined to evaluate the system.

Lei [9] presented an audio watermarking system on differential technique using dither modulation (DM) quantization. As a first phase Lifting Wavelet Transform (LWT), DWT are applied to decompose the signal and Discrete Cosine Transform (DCT) [10] is applied to the obtained sub-bands. SVD is applied to the DCT co-efficient and enhances the robustness of the system. Using the audio statistics synchronization code is inserted. DE optimization system is used for improving the imperceptibility.

Talat Naheeda et. al [11] has presented a reversible watermarking system. The proposed system is based on the additive interpolation-error expansion techniques with addition to two intelligent optimization algorithms. GA and PSO is incorporated to enhance the storage capacity and the also imperceptibility of the watermarking system. The system gives better quality and payload of watermarking.

Asma [12] suggests Bee Algorithm for watermarking the images. The algorithm proves to be a new food foraging behaviour of honey bees for finding the coefficients. Kalaiselvan [13] suggests Cat Swarm Optimization (CSO) to embed the watermark in frequency domain through Least Significant Bits (LSBs). The watermark is extracted using rounding approach. Vibha Verma et.al [14] has presented a watermarking system based on the DWT and SVD [15] method. DWT is applied to host and watermark images and split into two equal images based on column basis. The split image is resized to host image size by padding zeros. The SVD is applied to cover image and PSO is used to choose select scaling factor. The inverse technique is applied to recover the wavelet sub-bands. The system is robust against the different types of attacks. Mona [16] presented Weighted Quantum PSO approach for watermarking approach with evolving populations using linearly decreasing weight parameter and proves to achieve better values in global and local searches of PSO algorithm. Tran et.al [17] suggested method for optimization using PSO. The method uses DCT subband is selected using Genetic algorithm and strength of the watermark is selected using PSO. In this above section, relevant works on the digital watermarking with different techniques are summarized. In Section 2, proposed method is described. In Section 3 explains the methodology used. In Section 4 explains about the results and discussions suggested method.

2. THE PROPOSED METHOD

Watermarking method is suggested to increase robustness and imperceptibility of the digital watermark. Figure 1 represents system architecture of watermarking system for embedding the watermark to input image. The input and watermark images are provided as the input into the system; SWT and SVD is adapted to find the high coefficients and find the singular value of both the images. Among the three coefficients of SVD, only S coefficient of input image is given PSO algorithm to find the optimum location for embedding. The output of PSO algorithm is to produce S_{new} coefficients by calculating $gbest$ and $pbset$. S_{new} coefficient of the input image is combined with S coefficient of the watermark. As a next step find inverse of SVD and SWT to reconstruct the watermarked image. The output of the system is watermarked image. Figure 2 shows the extraction procedure of watermarked image and send it to the receiver end. The receiver receives watermarked image as an input and extract the watermark from it. PSNR and CC are calculated to check the performance of the proposed system.



Figure 1. proposed system architecture for watermark embedding

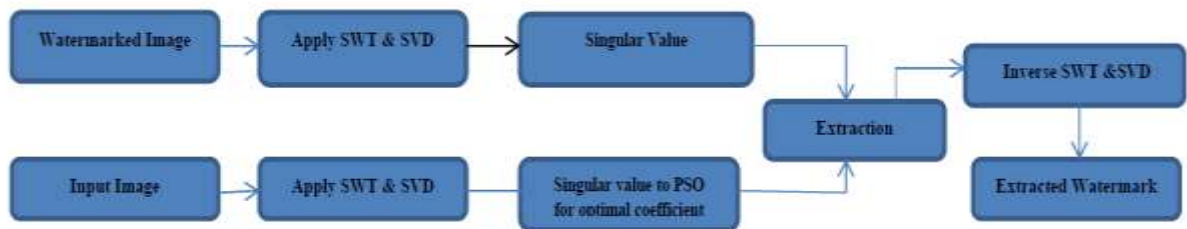


Figure 2. proposed system architecture for watermark extraction

3. RESEARCH METHOD

3.1. Stationary Wavelet Transform (SWT)

SWT is an un-decimal wavelet transform. The translation-invariance property of SWT makes the method more capable with the other transformations like DWT, DCT etc. SWT gives the output with every level contains the equal number of samples as the input. As we apply SWT it will decompose the image into high and low bands. High band is considered for further processing. Figure 3 shows the sub-bands created from the SWT [18, 19].

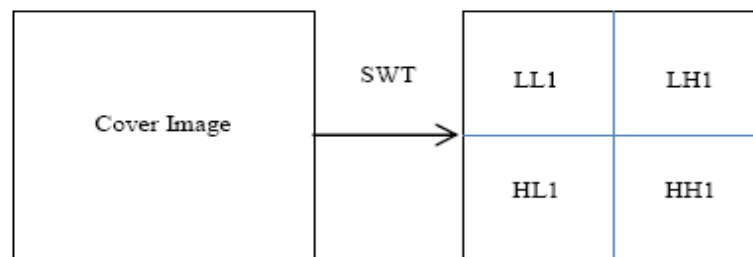


Figure 3. Sub-bands created from the SWT

3.2. Singular Value Decomposition (SVD)

SVD is used in linear algebra as a good mathematical tool. The purpose of using SVD is it is more robust and less prone to errors. In our method SVD is applied to HH sub-band, a matrix can be decomposed into three matrices given in (1). All the three matrices are of the same size as the original matrix. Given a real $n * n$ matrix A in (2), this matrix can be transformed into three components, U, D and V , respectively (3), such that

$$[U D V] = SVD(A) \tag{1}$$

$$A' = UDV^T \tag{2}$$

$$= \begin{bmatrix} u_{1,1}, \dots, u_{1,n} \\ u_{2,1}, \dots, u_{2,n} \\ \vdots \\ \vdots \\ u_{n,1}, \dots, u_{n,n} \end{bmatrix} \begin{bmatrix} \sigma_{1,1}, 0, \dots, 0 \\ 0, \sigma_{2,2}, \dots, 0 \\ \vdots \\ \vdots \\ 0, 0, \dots, \sigma_{n,n} \end{bmatrix} \begin{bmatrix} v_{1,1}, \dots, v_{1,n} \\ v_{2,1}, \dots, v_{2,n} \\ \vdots \\ \vdots \\ v_{n,1}, \dots, v_{n,n} \end{bmatrix}^T \tag{3}$$

$$= \sum_{i=1}^n \sigma_i u_i v_i^T \tag{4}$$

Where n represents A matrix rank as in (4)A' is the regenerated matrix after the inverse SVD transformation [20-22]. SVD has a constancy property that do not disturb the visual characteristics of the digital information even if there is deviation of singular values.

Algorithm: Watermark Image Embedding

Input: Input Gray Scale Medical Image as input and standard image as watermark

Output: Watermarked image

Steps for Watermarking at the Sender Side

- Step.1: Consider Gray input and watermark images of size 512X512
- Step.2: Apply SWT to Input image
- Step.3: Choose HH band
- Step.4: Apply SVD to HH band
- Step.5: Select only S of Input Image (Host Image S Value (H_S))
- Step.6: Apply SWT to Watermark Image
- Step.7: Apply SVD to HH band of SWT
- Step.8: Select S Value from the SVD Output(Watermark Image S Value (W_S))
- Step.9: Apply PSO to H_S value of the Input Image.
- Step.10: Embed the H_S to W_S image. S_WM=H_S+a*W_S
- Step.11: Apply ISVD, ISWT
- Step.12: Output Image is Watermarked Image
- Step.13: End algorithm

The same algorithm steps are repeated at the other end to retrieve the watermark from the received watermarked image.

3.2. Particle Swarm Optimization (PSO)

PSO is stochastically well known global optimization technique. The coefficient selection is very important factor in watermarking process. The PSO algorithm is used in watermarking to pick the best location in the selected band to encode the watermark into the host image. Figure 4 depicts the flow of PSO [23] technique. In PSO, the solution for each problem is known as ‘particle’. Every particle takes its ‘mean’ and ‘standard deviation (SD)’ related with it. As a first step the Mean and Standard Deviation (SD) of a particle is selected randomly. The finest mean of a particular particle achieves throughout the search for the solution is labeled as ‘pbest’. Similarly, the best mean among all the particles that has been considered throughout the search for solution is marked as ‘gbest’. The PSO tool contains of driving the mean of the particles towards their particular pbest and gbest solution. Once all the particles attain mean values the search for the solution to the problem stops [24].

Let i^{th} particle in D-dimensional space is defined as in (5)

$$X_i = (x_{i1}, x_{i2}, \dots, x_{iD}) \tag{5}$$

The particle i^{th} of swarm population has the knowledge of its personal best mean given in (6)

$$p_i = (p_{i1}, p_{i2}, \dots, p_{iD}) \tag{6}$$

The global best mean is given as in (7)

$$p_g = (p_{g1}, p_{g2}, \dots, p_{gD}) \tag{7}$$

The current SD is given as in (8)

$$v_i = (v_{i1}, v_{i2}, \dots, v_{iD}) \tag{8}$$

The particle modify their SD and according to the following (9) and (10)

$$v_{id} = w * v_{id} + c_1 * rand_1 * (p_{id} - x_{id}) + c_2 * rand_2 * (p_{gd} - x_{id}) \tag{9}$$

$$x_{id} = x_{id} + v_{id} \tag{10}$$

Where inertia weight w is equal to 0.9, $rand_1$ and $rand_2$ are the two random function within range of [0 1] for i^{th} particle, c_1 and c_2 constants are equal to 2, in the beginning SD is set at particle is 50 and 100 maximum iterations are used. The fitness function used for our method is shown in (11) Fitness function value range is from 0.9 to 0.2.

$$\text{fitness function} = \text{abs}(\text{mean}) + \text{abs}(\text{SD}); \tag{11}$$

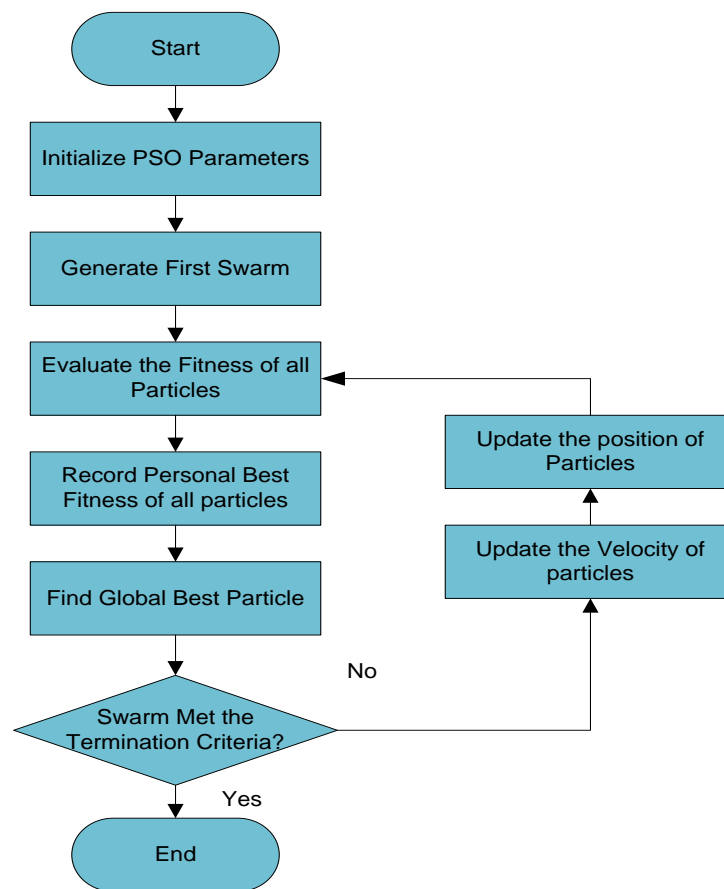


Figure 4. Flow chart for PSO

4. RESULTS AND DISCUSSION

The suggested method is experimented with Matlab R2012a tool by considering both input and watermark images with [512X512] in dimension. The experiment is conducted using fundus images [25] are considered as input images with four different watermarks are considered for the testing purpose. The above figure is the result of embedding and extraction for the suggested method where Figure 5(a) represents input, Figure 5(b) depicts watermark Figure 5(c) shows watermarked and Figure 5(d) provides the extracted watermark images respectively. PSO calculates the optimized value to embed the watermark image. Figure 6 shows the iteration conducted on S value of SVD. The maximum iteration carried using PSO in the proposed system is 100.

Extraction of watermark from the watermarked image is reverse procedure. The SWT is applied to watermarked image to get HH sub-band after this process SVD is applied. The coefficients are selected using the PSO, from those coefficients watermark image is obtained. Two types of noises are tested namely Salt and pepper and Gaussian noise on watermarked image from one percent to five percent. Figure 7 shows the range of a noise to be added to the watermarked image, user can choose the range of noise from 0.01 to 0.05. Figure 8 shows the addition of noise for the watermarked image.

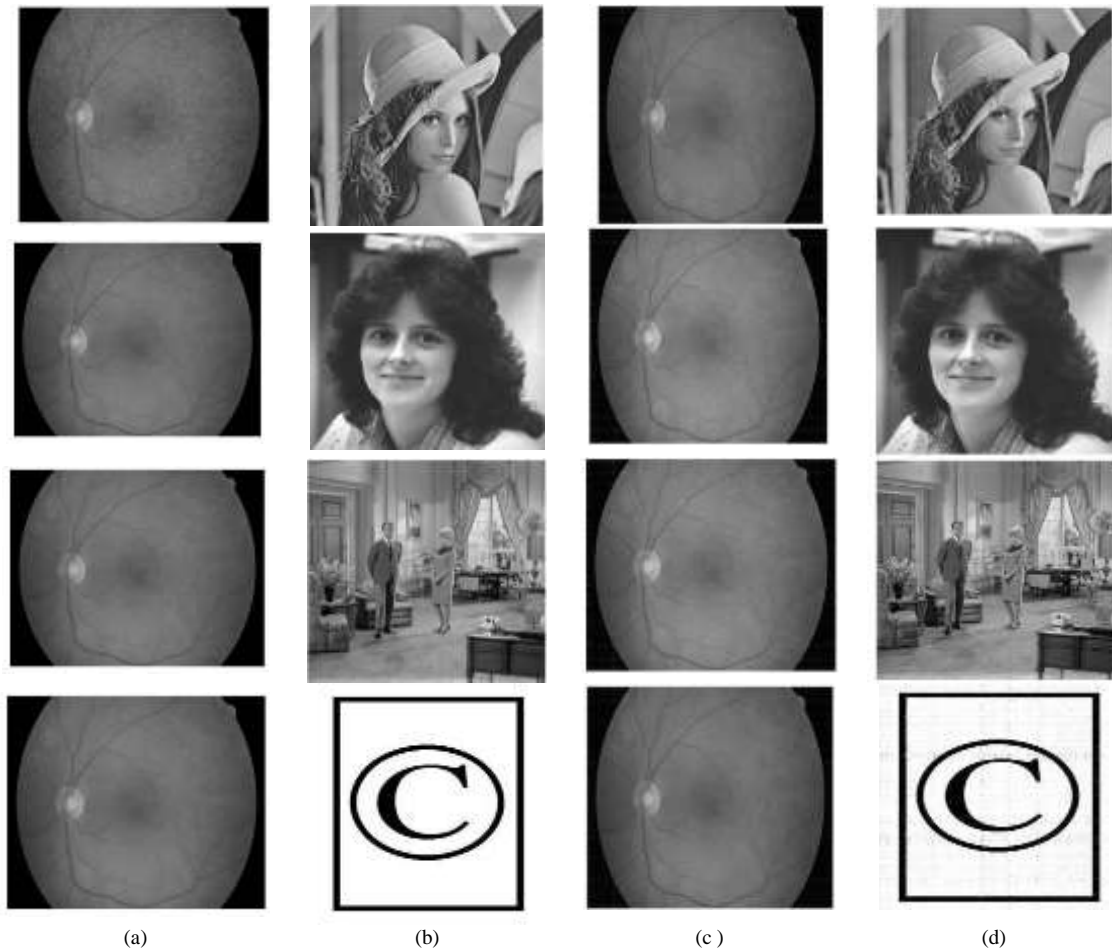


Figure 5. Input, watermark, watermarked and extracted watermark images

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Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.
Iteration# 93 Swarm.GBEST.O = 48.4727
Iteration# 94 Swarm.GBEST.O = 48.4727
Iteration# 95 Swarm.GBEST.O = 47.6533
Iteration# 96 Swarm.GBEST.O = 47.1233
Iteration# 97 Swarm.GBEST.O = 47.1233
Iteration# 98 Swarm.GBEST.O = 46.416
Iteration# 99 Swarm.GBEST.O = 46.0149
Iteration# 100 Swarm.GBEST.O = 46.0149
Best solution found
    
```

Figure 6. Iteration carried using PSO

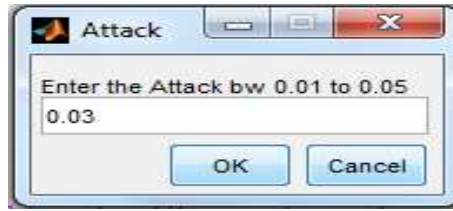


Figure 7. Noise range selection

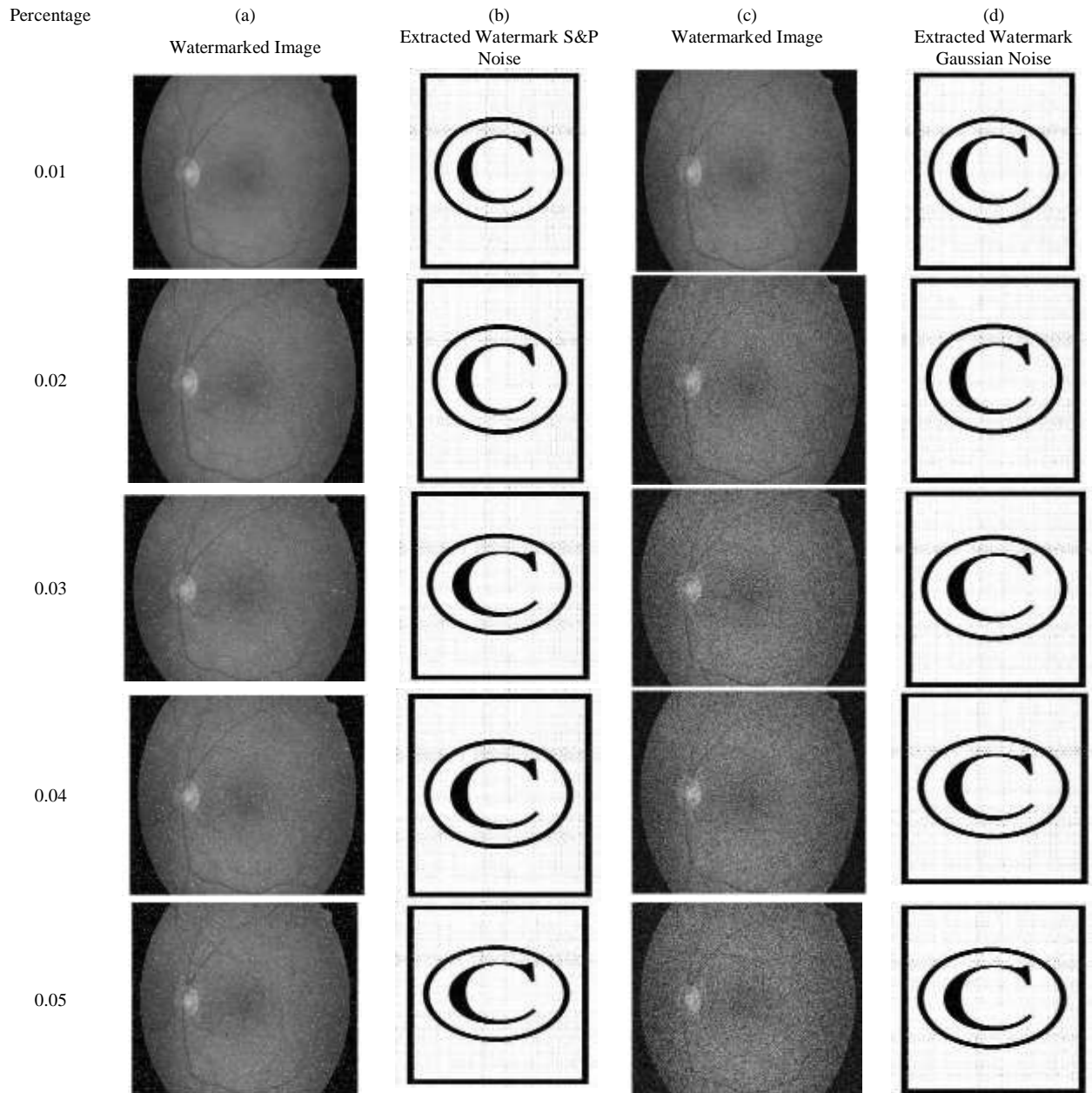


Figure 8. Applying attacks on watermarked image

Figure 8(a) indicates the watermarked Figure 8(b) extracted watermark after applying salt and pepper noise to the watermarked image with the noise ranges from 1 percent to 5 percent. Figure 8(c) indicates the watermarked Figure 8(d) extracted watermark after applying Gaussian noise to the watermarked

image with the noise ranges from 1 percent to 5 percent. The observed fact from the above figures are as we increase the percentage of noise the watermarked image quality will become poor, but still we can able to extract the watermark from the valued watermarked images. The performance of the system is verified using PSNR and CC. The imperceptibility of the images are measured using PSNR between host and watermarked image. Standard PSNR function is used in (12) where MSE is the mean square error between the two images.

$$PSNR = 10\log_{10} \left[\frac{255 \times 255}{MSE} \right] \tag{12}$$

To check the similarity between original and extracted watermark Correlation Coefficient is used as in (13):

$$CC = \text{corrcoef}(\text{Input Watermark Image}, \text{Extracted Watermark Image}) \tag{13}$$

The method is tested with PSO and without PSO by applying different type of attacks as shown in Table 1 and Table 2 with 2 percent noise induced to the watermarked image.

The observations from the following tables

- a) Table 1 shows that with PSO we can achieve good PSNR of 54 DB than without using PSO method with 34 DB in salt and pepper noise.
- b) Further Table 1 shows the value of PSNR without attacks. With PSO 53 DB and without PSO it is 74 DB.
- c) Table 2 presents the results of PSO algorithm in Gaussian noise attack. 52 DB of PSNR is achieved when we use PSO algorithm and without PSO method with 30 DB in case of Gaussian noise.
- d) In addition to the above results Table 2 shows PSO and without PSO results with no more noise induced into the system.

Table 1. Performance Report for Salt and Pepper Noise

Watermark Image	With PSO & Attack		Without PSO & With Attack		With PSO & without Attack		Without PSO & Without Attack	
	Salt and Pepper Noise [0.02]							
	PSNR	CC	PSNR	CC	PSNR	CC	PSNR	CC
Lena	54.297	0.972	34.6852	0.9851	53.2557	0.96433	73.43	0.99
Living Room	54.189	0.967	34.7927	0.9853	53.0194	0.95	74.700	0.99
Women Dark hair	54.369	0.978	34.9006	0.9891	52.2925	0.9719	78.262	0.99
Copyright	54.01	0.954	34.8072	0.9847	52.7795	0.96672	75.700	0.99

Table 2. Performance report for Gaussian Noise

Watermark Image	With PSO & Attack		Without PSO & Attack		With PSO & Without Attack		Without PSO & Without Attack	
	Gaussian Noise [0.02]							
	PSNR	CC	PSNR	CC	PSNR	CC	PSNR	CC
Lena	52.6176	0.9588	31.4343	0.99943	52.9686	0.96196	73.6235	0.99
Living Room	52.7104	0.9532	30.6826	0.99907	52.9724	0.95654	73.4343	0.99
Women Dark hair	52.612	0.9592	30.262	0.99985	53.1025	0.97656	71.6826	0.99
Copyright	52.715	0.9612	32.0473	0.99983	52.9213	0.96774	78.0473	0.99

Table 3(a) and Table 3(b) depicts the comparison of different author methods and suggested method. It has been proved that our method provides good results with the state of art techniques in terms of PSNR and CC. Table 4 depicts the results of our previous method and this method. Suggested method provides more robustness against attacks.

Table 3(a). Comparison of Existing and Proposed System of PSNR

Host Image	Reference	PSNR
lena	Talat Naheed [11]	49.00
lena	Asmatullah [17]	48.1057
lena	Millie [4]	45.1242
lena	Proposed system	54.36

Table 3(b). Comparison of Existing and Proposed System of CC

Input Image	Watermark	Reference Paper	CC
X-Ray	Copy Rights Reserved	Rohit Thanki [10]	0.7054
Iris	Copyrights	Proposed system	0.95748

Table 4 Comparison of Our Method with Previous Method [19]

Input Image	Watermark	Salt and Pepper Noise 5 Percent	CC
Medical Image [19]	Copyrights	30 DB	0.93
Medical Image [proposed method]	Copyrights	52 DB	0.97621

5. CONCLUSION

Nowadays, the transmission of medical information from one place to other place using internet has become very challenging task. Since the medical information is a sensitive data used for diagnosis purpose it should be secured against breaches and vulnerabilities. Our paper concentrates on providing security for the medical data using digital watermarking system. The suggested method uses medical image as input image and standard images as watermark images. SWT and SVD techniques are applied to both watermark and input image. PSO is used to get the optimal coefficient to embed the watermark image. Our suggested scheme is a reversible method; original and standard images can be retained which is very crucial because of the sensitivity of medical images. Experiment shows that our method provides better results than the previous methods.

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