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DWT SVD BASED SEGMENTED WATERMARKING SCHEME USING GENETIC ALGORITHM

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Abstract

A multiple color image segmented watermarking scheme based on discrete wavelet transform (DWT) and singular value decomposition (SVD) is presented. In the proposed approach, the original image is segmented into two sub images, and then the two color watermarks are embedded in the singular values of each sub image separately. In the extraction process the watermarks are extracted from the singular values of the watermarked sub images. The segmentation of multiple watermarking processes makes the watermarks much more robust to the attacks such as noise, filtering, compression, rotation, cropping, translation, sharpening, smoothing, row-column blanking Intensity transformation, and row-column copying. The optimization on segmented watermarking achieves more imperceptibility and robustness.

Keywords:

Discrete Wavelet Transforms, Singular Value Decomposition, Segmented Watermarking, Optimization, Genetic Algorithm

1. INTRODUCTION

A natural adaptive systems and designing artificial adaptive systems are studied in [1]. Genetic algorithms are adaptive heuristic search algorithms based on the evolutionary information of natural selection and genetics. Today genetic algorithms are used to resolve complicated optimization problems in a variety of industries including manufacturing, financial modelling, engineering, data mining, design and science. Some examples are travelling salesman problems (vehicle routing), scheduling problems (Multiprocessor scheduling) and Packing problem (shipping container operations).

An information-theoretic model for steganography with a passive adversary is proposed in [2]. The security of a steganographic system is quantified in terms of the relative entropy between the distributions of C and S, which yields bounds on the detection capability of any adversary. It is shown that secure steganographic schemes exist in their model provided the cover text distribution satisfies certain conditions. Mazumdar et al. [3] proposed a new steganalysis algorithm is described based on the MRF model of image LSB plane. In their framework the limitation of the Cachin's definition of the steganography capacity is quantified and a new measure is proposed.

Apurba Das et al. [4] addressed compressed images and found relatively redundant DCT coefficients for data embedding with maximized capacity. In their concept of psycho-visual salience and DCTune is combined to judge the capacity of each region of an image and the interpretation of salience in frequency domain is exploited to ensure the watermarking technique. Yamuna and Sivakumar [5] proposed a novel watermarking scheme for copyright protection in digital images. Their non-blind approach requires an original image for extracting the watermark. A Good quality of watermarked image is assured through their proposed scheme from the higher PSNR values which is evident from the experimental result.

Jobin Abraham [6] proposed a method for tamper proof digital images using the technique of digital watermarking based on DWT. Their method can detect the portions in images that were exposed to the vector quantization kind of attacks and two essential requirements of the watermarking process for tamper detection, blind and robust, stands fulfilled by their proposed algorithm. Yamuna and Siva Kumar [7] presented a novel reversible watermarking scheme based on histogram modification for the authentication of military images. The Hash Message Authentication Code (HMAC) of the image is computed and embedded into the image for authentication.

The bits of extracting HMAC from the marked image and HMAC of the restored image are compared for authentication. Dejey and Rajesh [8] combined the two transforms such as Discrete Wavelet Transform–Fan Beam Transform (DWT-FBT) and Spatio-Chromatic Discrete Fourier Transform–Fan Beam Transform (SCDFT-FBT) for Color image watermarking. Their DWT-FBT domain shows superior performance than SCDFT-FBT domain in its resistance to compression, cropping, Color conversion and rotation. Hu et al. [9] proposed an effective image forgery detection method that identifies a tampered foreground or background image using image watermarking. Experimental results demonstrate that their proposed method performs well in terms of image forgery detection.

A review of multiple watermarking for text documents is presented in [10]. Their multiple watermarking approach increase the watermarking capacity and tamperproof performance and also increases the security, robustness and invisibleness. To elaborate the suitability of wavelet transform for image watermarking and image watermarking process, analysis and classification of wavelet based watermarking techniques is proposed in [11]. A novel frequency domain based blind robust watermarking algorithm, which provides that embeds and extracts the watermark information effectively [12]. The experimental results demonstrated that their method is highly robust against attacks.

A new semi-blind reference watermarking scheme based on discrete wavelet transform (DWT) and singular value decomposition (SVD) for copyright protection and authenticity [13]. Experimental evaluation demonstrates that their proposed scheme is able to withstand a variety of attacks with the ambiguity attack also. A robust image watermarking algorithm the DWT (Discrete Wavelet Transform) and SVD (Singular Value Decomposition) have been used to embed two watermarks in the HL and LH bands of the host image [14]. Simulation evaluation demonstrates that their technique withstand various attacks. A new embedding and extracting scheme with hybrid DWT-SVD watermarking algorithm, to improve the robustness and imperceptibleness and to avoid the lack of watermark [15]. Their hybrid technique leads to optimize the conflicting requirements. Chaitanya et al. [16] proposed a digital Color image watermarking scheme using DWT- DCT coefficients in RGB planes. Their watermarking technique is increasing the security of data hiding, robustness and quality.

Wheeler et al. [17] introduced the notion of weighted segmented watermarking of still images in which segments are formed by dividing the image into square blocks, each of which contains one contributor's watermark. Hamed Dehghan and Ebrahim Safavi [18] presented a new wavelet-based image watermarking technique which is suitable for image copyright protection. Their method the host image was segmented into small blocks and the watermark data were embedded in the low pass wavelet coefficients of each block. Their simulation results show that the imperceptibility of the watermarked image and the robustness of the watermark against several attacks. The robust image watermarking scheme, the first image is segmented into a number of homogeneous regions, the segmented image is modelled as mixture generalized Gaussian distribution and their model is the basis of mathematical analysis of various aspects of the watermarking process such as probability of error and embedding strength adjustment [19]. The experimental results show that their algorithm performed well against rotation, scaling, and other attacks.

Lai et al. [20] proposed a digital watermarking scheme based on singular value decomposition and micro-genetic algorithm. Experimental results show that their approach has better performance against several attacks used the micro-genetic algorithm. Lai [21] proposed a digital watermarking scheme based on singular value decomposition and tiny genetic algorithms. They used the tiny genetic algorithm to search the proper values in order to improve the visual quality of the watermarked image and the robustness of the watermark.

An Image watermarking scheme based on Edge detection, Singular Value Decomposition, Quantization and Genetic algorithms have been presented in [22]. The quality of the watermarked image is good in terms of perceptibility and robust to various attacks, like, median filtering, low pass filtering, rotation, JPEG compression, resizing, salt and pepper noise attack, row column blanking and row column copying attack. Li et al. [23] proposed efficient cellular automata based watermarking method of this paper, multiple ownership watermarks are first recorded in the form of an elemental image array and then the recorded EIA as the watermark information is embedded into the CAT coefficient. Experimental results demonstrate that their proposed technique provides good image quality and is robust to some image processing attacks.

This paper is organized as follows; the relevant studies are explained in section 2. The proposed algorithm is explained in section 3. The experimental results and discussion are presented in section 4. The Genetic algorithms on segmented watermarking are presented in section 5. The Final conclusion of the present work is given in section 6.

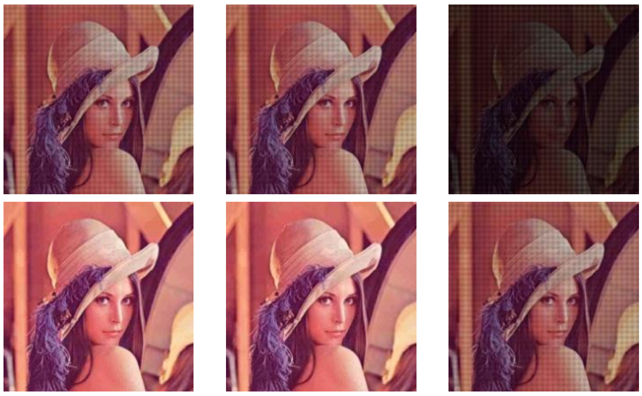
2. RELEVANT STUDY

2.1 DWT-SVD BASED WATERMARKING

In recent years, several digital image watermarking algorithms have been proposed based on discrete wavelet transform (DWT) and Singular Value Decomposition (SVD). The wavelet transform is based on small waves has gained widespread acceptance in signal processing and image compression. Wavelet-coding is especially suitable for the applications of tolerable degradation and scalability. The wavelet analysis is the heart of multi resolution analysis, decomposition of an image into sub images of different size resolution levels. The proposed method is the two level wavelet decomposition of original image and the watermark is applies to the low frequency sub band (LL_2). Singular value decomposition is a mathematical approach with several applications in watermarking, image compression, and other signal processing areas. In SVD-based watermarking algorithms add the watermark information to the singular values of the diagonal matrix S in such a way to meet the robustness and imperceptibility requirements. If the watermark is added in the orthogonal matrices of SVD then the imperceptibility of the original image is improved, it is not robust to many attacks because the matrix elements of orthogonal matrices are very small.

2.2 MULTIPLE SEGMENTED WATER MARKING

The segmented watermarking method performs a segmentation of the original image so that each watermark has its own separate embedding area. The Fig.1 shows the block diagram of multiple segmented watermarking by using line segmentations. The Fig.1(a) shows odd-numbered rows and even-numbered rows of Lena image. The Fig.1(b) shows odd-numbered columns and even-numbered columns of Lena image. The Fig.1(c) shows odd-numbered rows and columns and even-numbered rows and columns of Lena image.



(a) (b) (c)

Fig.1. (a) Odd and Even-Numbered Rows (b) Odd and Even-Numbered Columns (c) Odd and Even-Numbered Rows and Columns

In the proposed work one watermark is embedded into odd-numbered rows and columns and another watermark is embedded into even-numbered rows and columns in color image of Lena.

3. PROPOSED SCHEME

The proposed scheme DWT- SVD based multiple segmented watermarking schemes using genetic algorithm. The Watermark embedding, extraction and genetic algorithm process is discussed below.

3.1 WATERMARKING EMBEDDING PROCESS

The watermarks used for embedding is a color image, which is small compared with the size of the original image. The flowchart for multiple segmented watermarking of the watermark embedding process is shown in Fig.2. The steps for watermark embedding are briefly listed as follows,

1. The original image (I) is segmented into two sub images such as odd sub image (I_{odd}) and even sub image (I_{even}). The odd and even sub image is decomposed by two levels by using discrete wavelet transform.
2. The SVD process is applied to LL_2 sub band of odd and even sub image
$$I_{odds} = U_{odds} S_{odds} V_{odds}^T \quad (1)$$
$$I_{evens} = U_{evens} S_{evens} V_{evens}^T \quad (2)$$
3. Similarly, the SVD process is applied to watermark Image1 and watermark image2
$$W1 = U_1 S_1 V_1^T \quad (3)$$
$$W2 = U_2 S_2 V_2^T \quad (4)$$
4. The singular value of watermark image1 is embedded in the singular value of odd sub image and the singular value of watermark image2 is embedded in the singular value of even sub image, such that
$$S_{oddsWI} = S_{odds} + \alpha S1 \quad (5)$$
$$S_{evensWI} = S_{evens} + \alpha S2 \quad (6)$$
Here α is the scaling factor which determines the strength of the watermark. The best results are obtained based on the parameter α, which is chosen by trial and error method.
5. The inverse SVD process is applied,
$$I_{oddsWI} = U_{odds} S_{oddsWI} V_{odds}^T \quad (7)$$
$$I_{evensWI} = U_{evens} S_{evensWI} V_{evens}^T \quad (8)$$
6. The inverse wavelet transform is performed to get odd and even watermarked sub images.
7. The two sub images I_{oddsWI} and $I_{evensWI}$ are combined to get a final watermarked image.
8. The performance of watermarking technique can be evaluated by peak signal to noise Ratio (PSNR) is used to measure the imperceptibility of watermarked image, which is specified by,
$$PSNR(dB) = 10\log_{10}\frac{255^2}{MSE} \quad (9)$$

3.2 WATERMARKING EXTRACTION PROCESS

The watermark extraction processes are reverse shown in Fig.3. The steps for watermark extraction are briefly listed as follows,

1. The watermarked image is segmented into two sub images such as odd watermarked sub image (I_{oddsWI}) and even watermarked sub image ($I_{evensWI}$).

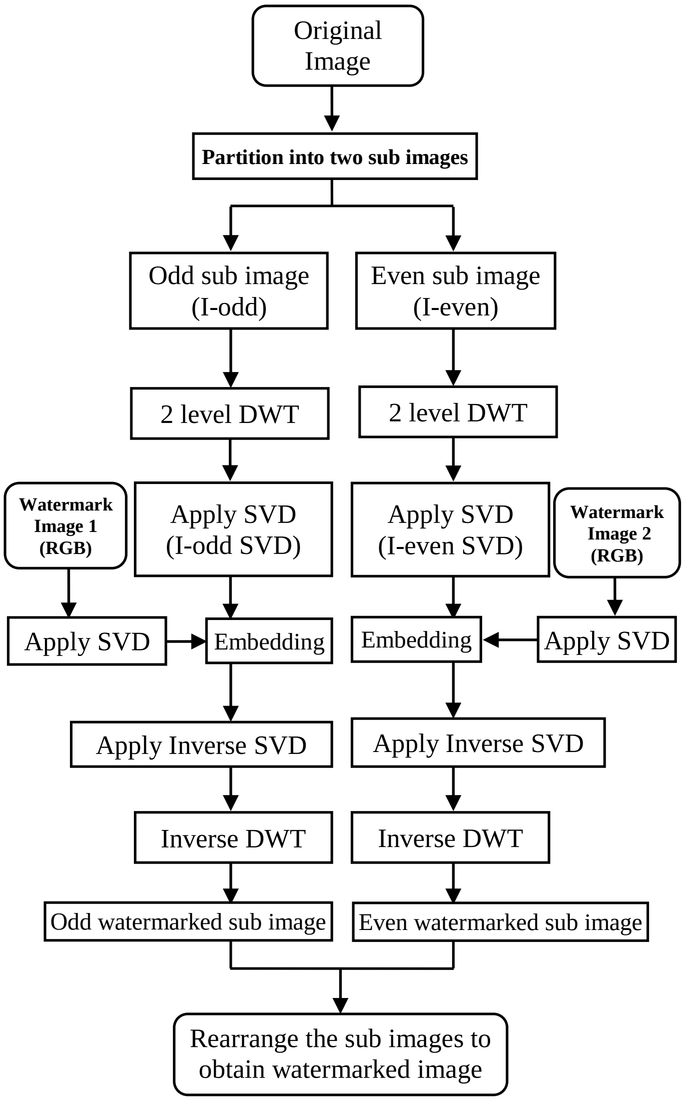


Fig.2. Flowchart for watermark embedding

2. The odd and even watermarked sub image is decomposed by two levels by using discrete wavelet transform.
3. The SVD process is applied to LL_2 sub band of odd and even watermarked sub image,
$$I_{oddsWI} = U_{odds} S_{oddsWI} V_{odds}^T \quad (10)$$
$$I_{evensWI} = U_{evens} S_{evensWI} V_{evens}^T \quad (11)$$
4. The singular values of watermark image1 and watermark image2 can be extracted as
$$S_1' = \frac{\left(S_{oddsWI} - S_{odds}\right)}{\alpha} \quad (12)$$
$$S_2' = \frac{\left(S_{evensWI} - S_{evens}\right)}{\alpha} \quad (13)$$
5. The inverse SVD process is applied to get watermark image1 and watermark image2
$$W_1 = U_1 S_1' V_1^T \quad (14)$$
$$W_2 = U_2 S_2' V_2^T \quad (15)$$

6. Normalized Correlation (NC) is used to measure the robustness of the watermark after extraction. The NC between the extracted watermark $W'(i,j)$ and the embedded watermark $W(i, j)$ is defined as,

$$NC = \frac{\sum_{i=1}^{H}\sum_{j=1}^{L} W(i,j)\times W'(i,j)}{\sum_{i=1}^{H}\sum_{j=1}^{L}\left[W(i,j)\right]^{2}} \tag{16}$$

3.3 GENETIC ALGORITHM PROCESS

In this present work, the genetic algorithm is utilized for solving the optimization problem in watermarking. In the watermarking algorithm PSNR and NC are the two important characteristic parameters. These two parameters must be as large as possible for a superior watermarking algorithm. However PSNR and NC are associated in such way that maximization of PSNR reduces the value of NC. Hence, the watermarking algorithm with genetic algorithm is used to find the best values of parameters to obtain a specified performance of the watermarking system in terms of PSNR and NC.

The steps involved in the genetic algorithm process in the current work are listed below,

1. Initialize the parameters are crossover rate, mutation rate, initial population size and number of iterations.
2. Generate the initial population randomly specified by performing the watermark embedding and extraction process, as the attacked watermarked image and extracted watermark is generated for each individual.
3. The selection of fitness function is based on the magnitude of imperceptibility and robustness as follows,

$$\textit{Fitness Function} = PSNR + (100 \times NC_1) \tag{17}$$

$$\textit{Fitness Function} = PSNR + (100 \times NC_2) \tag{18}$$

4. In Eq.(17) and Eq.(18), if the value of 100 is multiplied with NC, the fitness value increases more with the increase in the value of NC rather than PSNR. So, optimization of robustness takes place for a given value of imperceptibility. The robustness value has positive correlation with fitness function.

$$\textit{Fitness Function} = NC + (100 \times PSNR) \tag{19}$$

5. Here the NC value is the average value of two watermarks. In Eq.(19), if the value of 100 is multiplied with PSNR, the fitness value increases more with the increase in the value of PSNR rather than NC. So, optimization of imperceptibility takes place for a given value of robustness. The imperceptibility value has positive peak signal to noise ratio with fitness function.
6. Select the best fitness value and the best individuals.
7. Generate the new population randomly specified by performing the crossover, mutation functions on the selected individuals.
8. Repeat the above steps until a predefined iteration is reached.

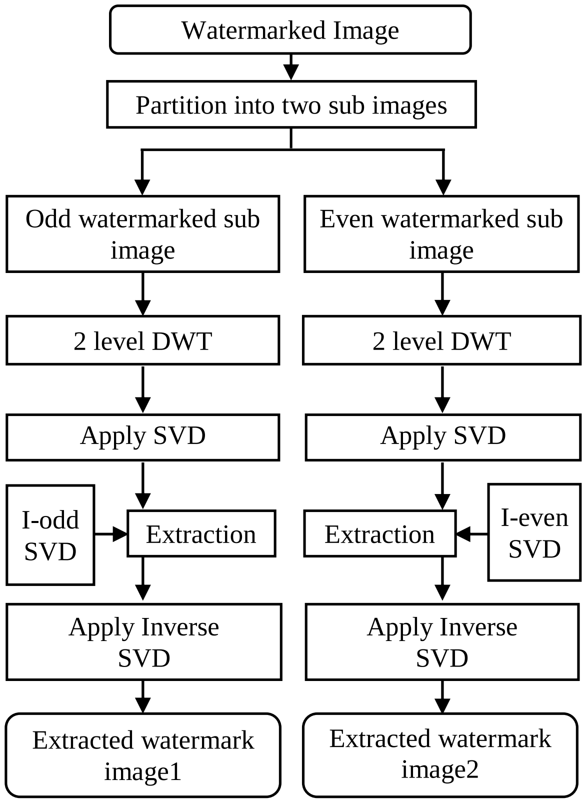
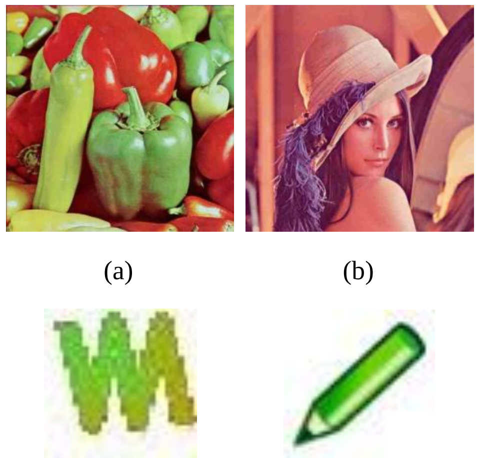


Fig.3. Flowchart for watermark extraction

4. RESULTS AND DISCUSSION

In this paper, a robust multiple segmented watermarking technique is proposed based on wavelet domain for Color images. Fig.4(a) and Fig.4(b) shows the original images Peppers and Lena of size 512×512 and the Color image watermarks of size 48×48 as shown in Fig.4(c) and Fig.4(d).



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

Fig.4. (a) Peppers (b) Lena (c) Watermark image1 (d) Watermark image2

4.1 ANALYSIS ON DIFFERENT WATER MARKING TECHNIQUES

The result from the Table.1 clearly shows the combination of the original image with DWT and SVD along the watermark with SVD displays high imperceptibility and robustness. While they are treated alone viz original image with DWT or the original image with SVD with watermark shows varying high and low values in either case.

Table.1. Comparison of imperceptibility and robustness of different image watermarking methods

Methods	Imperceptibility	Robustness
Original image + Watermark	Low	Low
(Original image with DWT) + Watermark	High	Low
(Original image with SVD) + (Watermark with SVD)	Low	High
Original image with DWT and SVD) + (Watermark with SVD)	High	High

Thus demonstrates the importance of by taking DWT and SVD in the original image along with watermark for watermarking. The Table.2 shows the watermarked images and extracted watermarks on different image watermarking methods.

4.2 SINGLE AND SEGMENTED WATER MARKING AGAINST DIFFERENT ATTACKS

To prove the robustness, the single and segmented watermarked images are tested with selected attacks such as salt and pepper noise, Gaussian noise, speckle noise, median filtering, wiener filtering, Gaussian blur, translation, cropping, rotation, JPEG compression, sharpening, smoothing, Intensity transformation, row-column blanking and row-column copying. The Table.3 shows the performance comparison of PSNR of single and segmented (multiple) watermarking techniques in Lena and peppers Color images. The Table.4 shows the performance comparison of NC of single and segmented (multiple) watermarking techniques for Lena and peppers color images.

The watermarked images are corrupted with salt and pepper noise at the density of 3%, Gaussian noise of variance 1% and speckle noise of variance 0.005. For median and wiener filtering are 3×3 mask consisting of 0.03 intercity values is used to reduce noise in the image. In cropping attack a small portion of the watermarked image is cut or removed. Rotation is tested by rotating the image in 60 degrees direction and then back to the original position through bilinear interpolation. The watermarked images are compressed with a 20 quality factor. The subjective quality is enhanced using the sharpening operations. A set of rows and columns are deleted from 150 to 180, 250 to 280 and 350 to 380 in a row-column blanking attack. In row-column copy attack, a set of rows and columns are copied to the adjacent or random locations. In this attack from 151 to 200 rows are copied to 251 to 300 and 251 to 300 rows are copied to 151 to 200.

Table.2. PSNR and NC values for watermarked images and extracted watermarks on different image watermarking methods

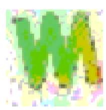
Methods	Single Watermarking			
	Peppers		Lena	
	PSNR (dB)	NC	PSNR (dB)	NC
Original Image + Watermark				
	41.7167	0.9675	41.7268	0.9675
(Original image with DWT) + Watermark				
	50.9008	0.6586	50.9085	0.6586
(Original image with SVD) + (Watermark with SVD)				
	41.9248	1.00	42.1390	1.00
(Original image with DWT and SVD) + (Watermark with SVD)				
	44.6749	1	44.3211	1

Table.3. Comparison of PSNR values on single and segmented watermarking methods

Attacks	Single watermarking PSNR(dB)		Segmented watermarking PSNR(dB)	
	Peppers	Lena	Peppers	Lena
Without attacks	44.6749	44.3211	38.0542	38.0639
Salt and pepper noise at the density of 3%	20.1591	20.3472	20.0629	20.2656
Gaussian noise of variance 1%	20.1031	19.2428	20.0289	20.2222
Speckle noise of variance 0.005	28.7176	27.9465	28.2598	27.6107
Median filtering for 3 × 3 filter size	33.6447	34.5822	33.4500	33.4168
wiener filtering for 3 × 3 filter size	20.2604	20.5740	20.2268	20.5544
Gaussian blur	29.1031	29.2428	28.7407	28.8764

Translation	16.2577	16.9247	16.2222	15.8991
Cropping	10.8386	11.1938	10.8184	10.6319
Rotation at 60 Degrees	8.8152	10.1057	8.7890	8.5919
JPEG compression with quality of 20	35.0573	21.8712	34.6695	35.2048
Sharpening	25.2774	25.6618	25.0689	23.9824
Smoothing	40.4968	41.1692	36.8160	36.4034
Intensity Transformation	22.6803	19.2650	22.7353	19.3213
Row-column Blanking	13.9256	11.9599	13.9140	11.9524
Row-column Copying	16.5699	18.7932	16.513037	18.7024

Table.4. Comparison of NC values on single and segmented watermarking methods

Attacks	Single watermarking		Segmented watermarking			
	Peppers	Lena	Peppers		Lena	
	NC	NC	NC1	NC2	NC1	NC2
Without attacks	1	1	1	1	1	1
Salt and pepper noise at the density of 3%	0.8966	0.8081	0.9553	0.9831	0.8856	0.9978
Gaussian noise of variance 1%	0.9307	0.9089	0.9557	0.9862	0.8769	0.9743
Speckle noise of variance 0.005	0.9412	0.9968	0.9519	0.9954	0.9965	0.9992
Median filtering for 3 × 3 filter size	0.9884	0.9928	0.9982	1	0.9993	1
Wiener filtering For 3 × 3 filter size	0.7470	0.6731	0.9342	0.9849	0.8142	0.7679
Gaussian blur	0.9307	0.9089	0.9845	0.9934	0.9873	0.9956
Translation	0.3410	0.5150	0.9676	0.9439	0.9586	0.9359
Cropping	0.3045	0.3354	0.3424	0.3636	0.3374	0.3600
Rotation at 60 degrees	0.1078	0.1351	0.1329	0.1290	0.1240	0.1187
JPEG compression with quality of 20	0.9585	0.8469	0.9806	0.9845	1	1
Sharpening	0.8842	0.8101	0.9137	0.9595	0.9078	0.9655
Smoothing	1	0.9989	1	1	1	1
Intensity transformation	0.8813	0.4758	0.8824	0.8841	0.4832	0.5179
Row-column blanking	0.6666	0.6670	0.6676	0.6705	0.6686	0.6705
Row-column copying	0.8469	0.8358	0.9541	0.9658	0.9211	0.9323

The experimental result shows that the segmented watermarking technique achieves more robustness, when compared with single watermarking technique and the image quality is degraded with every new watermark embedded into the image. To optimize the imperceptibility, segmented watermarking is tested by genetic algorithm presented in the next section.

5. GENETIC ALGORITHM ON SEGMENTED WATERMARKING

A segmented watermarking technique is proposed based on DWT and SVD by using genetic algorithm. The Table.5 shows the different payload capacity for salt and pepper noise attack at the density of 3%. The Table 6 shows the PSNR and NC values for selected attacks on segmented watermarking using genetic algorithm in Lena and Peppers Color images. The related genetic parameters that are used for our experiments are as follows: the population size is 20, the number of variables is 2, the probability of crossover is 0.8, the maximum number of generation is 5 and the probability of mutation is 0.2.

Table.5. Different payload capacity of Salt and pepper noise attack at the density of 3%

Parameters	Payload Capacity	PSNR	NC1	NC2
Population size is 10 The probability of crossover is 0.8 Maximum number of generation is 10 Probability of mutation is 0.2	512×512	20.3665	0.9105	1
	256×256	20.4592	0.8675	0.9926
	128×128	20.6964	0.9074	0.9992
Population size is 20 The probability of crossover is 0.8 Maximum number of generation is 5 Probability of mutation is 0.2	512×512	20.3710	0.8892	0.9981
	256×256	20.7059	0.9050	0.9978
	128×128	20.7257	0.9059	1

Table.6. PSNR and NC values for selected attacks on segmented watermarking using genetic algorithm

Attacks	Peppers			Lena		
	PSNR (dB)	NC1	NC2	PSNR (dB)	NC1	NC2
Salt and pepper noise at the density of 3%	20.2218	0.9689	0.9979	20.3710	0.889	0.998
Gaussian noise of variance 1%	20.2407	0.9676	0.9995	20.2425	0.8864	0.9873
Speckle noise of variance 0.005	28.8625	0.9814	0.9966	27.9107	0.9985	0.9998
JPEG compression with quality of 20	35.5136	1	1	36.7035	1	1
Median filtering for 3 × 3 filter size	33.7026	0.9992	1	33.5685	0.9997	1
wiener filtering for 3 × 3 filter size	20.2847	0.9428	0.9931	20.5878	0.8346	0.7803

The Fig.5 and Fig.6 shows the comparison of PSNR and NC values for single watermarking segmented watermarking and genetic algorithm. Simulation results show that the effectiveness of the proposed scheme by checking the fitness function in GA, which includes both factors related to the robustness under attacks (salt and pepper noise, Gaussian noise, speckle noise, JPEG compression, median filtering and wiener filtering) and the improvement in watermarked image quality with genetic algorithm.

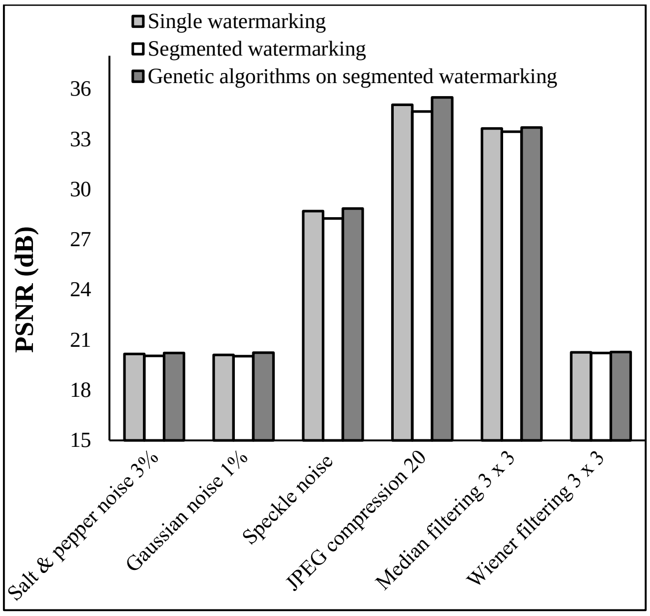


Fig.5. Comparison of PSNR values on selected attacks

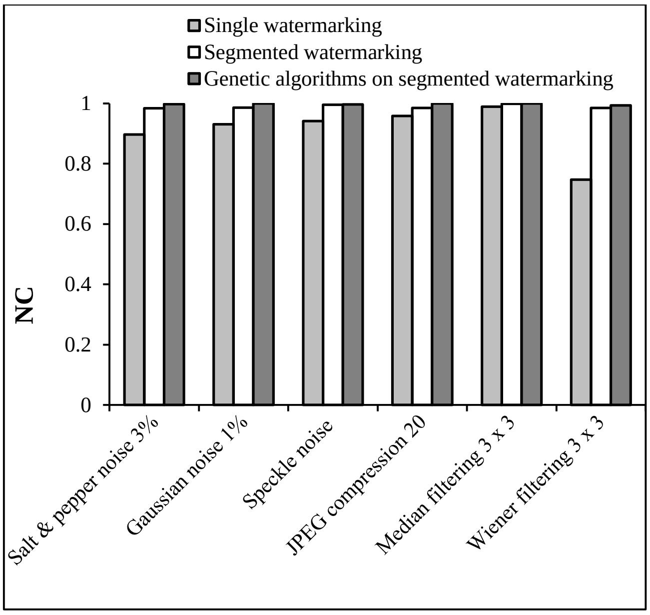


Fig.6. Comparison of NC values on Selected Attacks on Pepper Image

5.1 COMPARISON TO EXISTING METHOD

To prove the effectiveness of the proposed method, the results are compared with existing method [22]. An Image watermarking scheme based on Singular Value Decomposition with Genetic algorithm are presented in [22]. In comparison with the existing method [22], our proposed multiple watermarking method using genetic algorithm with stands for several image processing and geometrical attacks. The results are presented in Table.7. It is evident that the robustness of our proposed method is superior to existing methods for the Lena image.

Table.7. Comparison to existing method for different generations (5 and 15)

Attacks	**Generations**	**Existing Method [22]**	**Proposed Method Extracted Watermarks**	
			1	**2**
Salt and Pepper Noise	5	0.657		
			0.889	0.998
	15	0.652		
			0.889	0.998
Median Filtering	5	0.648		
			0.999	1
	15	0.633		
			0.999	1
JPEG Compression	5	0.749		
			1	1
	15	0.765		
			1	1

6. CONCLUSION

In this paper, the optimization of multiple segmented watermarking using genetic algorithm has been presented. The embedding and extraction process uses the multi resolution analysis of wavelet transform and singular value decomposition. The experimental result shows that the segmented watermarking technique achieves more robustness when compared to the single watermarking technique. The optimization is to maximize the performance of peak signal to noise ratio (PSNR) and normalized correlation (NC). Experimental results demonstrate that the present work achieves the good imperceptibility and robustness against attacks by using genetic algorithm. The performance of the proposed method is analyzed by comparing with the existing methods.

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