Role of Scaling Factor in Robust Digital Watermarking

Poonam Kadian, Nidhi Arora, Shaifali M Arora

Abstract*: Digital watermarking has been identified as an efficient tool to provide copyright authentication and protection of digital data. Robustness and Imperceptibility are the two key parameters in designing of watermarking system. It is always desired to design a watermarking system that provides excellent robustness to malicious attacks and the watermark is invisible to human eyes. The robustness and imperceptibility can be controlled by choosing an effective scaling factor. Scaling factor decides on the amount of insertion of watermark in the host image. Higher the value of scaling factor more visible the watermark will be in watermarked image, this leads to poor imperceptibility. However the increase in scaling factor leads to a more robust watermarking system. Finding a trade-off among both is the key issue of research in this area. This paper aims at describing the effect of selection of scaling factor on robustness and imperceptibility by taking different values of scaling factor during each watermarking process. The empirical analysis done in this work shows robustness can be improved at the cost of imperceptibility and vice-versa.

***Keywords*: Digital Watermarking, copyright protection, DWT, SVD, scaling factor, multimedia security.**

I. INTRODUCTION

To safeguard the digital data spread over social platforms from malicious attackers, a number of data hiding techniques such as cryptography, steganography and many more are available today. Digital watermarking techniques are one among them. Digital watermarking techniques have shown their tremendous capabilities in protection of digital works by safeguarding copyrights of owner on their data.

The two main constituents required in formation of any Digital Watermarking system are watermark insertion and watermark extraction. When certain data like image, text, and logo called watermark data is inserted into host data, it is known as insertion of watermark. The output of this process is called watermarked data. This watermarked data is then transmitted over the channel where it faces legal/ illegal attacks. The attacked data, when received by the user and verified for authenticity by extracting the watermark from received data, is known as the extraction process of Digital Watermarking [18]. The watermarked data is likely to be subjected to certain intentional/ unintentional modifications by the attackers. Some of the intentional modifications include compression and geometric attacks such as cropping, filtering. The unintentional modifications include resizing, resampling, and an addition of Gaussian or non-Gaussian noises, printing, rescanning and many more.

The foremost sought after characteristics from digital watermarking system are robustness and imperceptibility. For the security of watermark, it is desired that watermark is invisible to human eyes. This condition of invisibility refers to imperceptibility of the watermark. Robustness of watermark refers to the capability of watermark to sustain the attacks. The watermarked image is checked for the presence of watermark during extraction process and if watermark is present it gets matched with original watermark image for authenticity of extracted watermark. The other features considered while designing watermarking system include data payload, intricacy, capacity, computational cost, fragility. The application areas of digital watermarking include where copyright protection and/ or copyright authentication is required.

Spatial domain and transform domain are the two working domains adopted for digital watermarking [1-2]. In spatial domain watermarking, the pixels of host image are modified directly in accordance with the watermark used. These methods are computationally effective but lags in providing significant robustness and imperceptibility. Contrary to it, transform domain technique such as DCT, DFT, DWT, LWT etc. work on frequency coefficients of host image and hence are computationally costly, but are able to provide better performance in terms of robustness and imperceptibility.

The minimum requirement of robustness and imperceptibility in watermarking system can be attained either by embedding the watermark in the higher frequency components of the image or by choosing appropriate value of scaling factor.

The Scaling Factor (SF) is the controlling factor that determines the amount of external effect allowed inside the host data. With the higher value of scaling factor, the watermark may become visible to human eyes but this also improves robustness significantly. As the value of scaling factor gets reduced, the watermark becomes invisible at the cost of robustness. The choice of scaling factor thus plays a critical role in obtaining the desired trade-off between Imperceptibility and Robustness of a digital watermark. The objective of this paper is to provide an empirical analysis on the effect of selecting an appropriate value of SF. Different values for SF has been used to analyse the impact on Robustness and Imperceptibility in Digital Watermarking system.

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Two transform domain techniques discrete wavelet transform (DWT) and redundant discrete wavelet transform (RDWT) with and without hybridization has been considered to demonstrate the significance of selecting a correct value of SF.

The paper has been structured as follows. Section 2 provides an introduction to DWT, RDWT and SVD methods. The proposed algorithm and simulation results have been discussed in sections 3 and 4 respectively. The performance of proposed algorithms has been analyzed in terms of NC, PSNR, and SSIM. Section 5 presents the performance evaluation of both the algorithms followed by a conclusion.

II. TRANSFORM DOMAIN TECHNIQUES

A. DWT (Discrete wavelet transform)

DWT is mathematical tool used for decomposition of digital image. Applying DWT on 2-D images corresponds to passing the image through 2-D filters in each direction. After passing through the filters the image gets decomposed into four non overlapping multi resolution sub bands representing the coarse scale and fine scale of the image. N level decomposition can be performed over image resulting in 3N+1 sub bands. As DWT is localized both in time and frequency, it has become an efficient tool in locating the areas in host image where embedding of watermark will provide the best efficiency. In most of the images energy is concentrated at lower frequencies, embedding watermark in these frequencies will improve robustness significantly at the cost of deterioration of the image quality. The one level 2-D DWT process divides the image array horizontally and vertically resulting four sub bands LL, LH, HL, and HH as shown in figure 1. A one level 2-D DWT decomposition of Lena image has been depicted in Figure2.

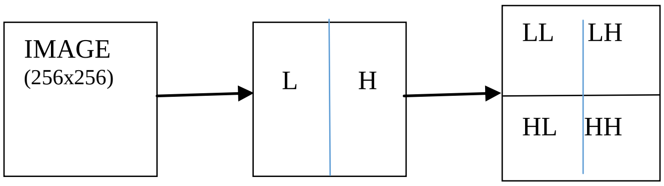


Fig. 1. The process of 2-D DWT decomposition (size of LL, LH, HL, and HH=128x128)

Fig. 2. One level 2-D DWT decomposition of Lena image
(Size of LL, LH, HL, and HH=128x128)

B. SVD (Singular Value Decomposition)

SVD is a widely used matrix decomposition technique. The other method that can be used in place of SVD is Eigen Decomposition, but since every rectangular matrix has an SVD, it makes SVD decomposition method a more stable method than other methods. In the process of SVD an MxN sized image gets decomposed as a 2-D MxN matrix and then SVD is applied over this MxN matrix to obtain three matrices namely U, S and V. The diagonal values of S matrix are known as singular values of matrix A, whereas the columns of U and V matrices are termed as left and right singular values of A respectively [13, 14].

Figure 3 illustrates decomposing of matrix A (MxN) resulting three SVD matrices as:

$A= USV^T$ (1)

Where U and V are square matrices and S is a rectangular matrix with the same dimensions as of matrix A.

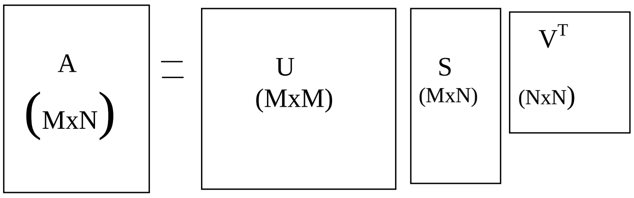


Fig.3. Illustration of Singular Value Decomposition process [10, 13]

C. RDWT (Redundant Discrete Wavelet Transform)

Spatial-frequency localization is the most useful property of DWT that makes this technique most sought after technique in image processing applications such as digital watermarking. But the down sampling operation that takes place at every decomposition level introduces shift variance in images which is not desirable. Due to shift invariance property and high pass filter operations performed on image, the size of the host image gets reduced by half at every decomposition level. This in turn reduces the data payload capacity of host image which leads to inaccurate extraction of watermark. The aforesaid limitations of DWT can be overcome by using another transform domain technique RDWT [16].

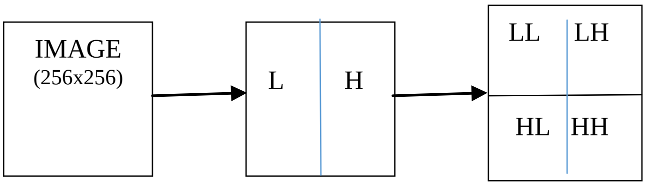


Fig. 4. The process of 2-D RDWT decomposition (Size of LL, LH, HL, and HH=256x256)

Figure 4 shows a one level decomposition process using RDWT with its sub bands (LL, LH, HL, and HH). Figure 5 presents the 2-D RDWT decomposition of Lena image. As seen from figure 4 and 5 the size of each decomposed sub band remains same as the size of host image. Since RDWT is able to overcome the limitations of DWT and hence offers more data capacity in host image, leads to generation of more robust watermarking systems.

Fig. 5. One level 2-D RDWT decomposition of Lena Image (size of LL, LH, HL, and HH=256x256)

III. PROPOSED ALGORITHM

In this section, the proposed watermarking algorithm using DWT-SVD and RDWT-SVD by keeping SF variable has been presented. The watermark embedding and extraction algorithms will remain same for both the techniques, except that in case of RDWT-SVD, SWT operation will be performed in place of DWT operation performed in DWT-SVD.

Herein the proposed algorithm, watermarked images have been acquired in the course of watermark embedding process for different values of scaling factors as 0.05, 0.1, 0.15, 0.25, 0.5, and 0.75. As discussed earlier, for lower values of SF embedded watermark remains less visible in watermarked image and hence imperceptibility is high with a compromise in robustness. As value of SF is increased imperceptibility gets degraded with significant improvements in robustness. So, the value of SF can be decided as per the application requirements.

The watermarked images have been examined for robustness and imperceptibility by imposing the watermarked images to different image processing and geometric attacks such as blurring, sharpening, resizing, rotation, salt and pepper noise, and Gaussian noise.

The Watermark Embedding Algorithm

Step1: Apply 2- level DWT on host image to extract sub bands LL, LH, HL and HH from the image.

Step 2: Apply SVD on LL sub band to get singular value coefficients.

Step 3: Apply SVD on the image to be used as watermark.

Step 4: Embed the Singular values obtained from step 2 and 3 by keeping SF variable. The amount of embedding watermark into host image is dependent upon the value of SF.

Step 5: Rebuild the lower sub band using SVD

Step 6: Apply Inverse DWT on lower sub band achieved from step 5 and get the watermarked image.

The Watermark Extraction Algorithm

Step6: Apply 2- level DWT on received (watermarked and probably attacked) image to extract sub bands LL, LH, HL and HH.

Step 7: Apply SVD on LL sub band obtained from step 1, to get singular value coefficients.

Step 8: Compare the singular values obtained in step 3 and step 7 and divide it by value of SF.

Step 9: Use the image obtained from step 8 and original watermark image to calculate CC (correlation) and SSIM (structural similarity index) of both images.

Step 10: Compare host image and received watermarked image to calculate PSNR (peak signal to noise ratio) of two images.

IV. EXPERIMENTAL RESULTS

To assess the influence of SF over the performance of the watermarking system, two standard 256x256 test images namely Lena and Crowd (.jpg format) have been used as input host images and one 256x256 binary image has been used a watermark and is shown in Figure6(a-c) [12]. Six different values for SF has been considered for experimentation (0.05, 0.1, 0.15, 0.25, 0.5 and 0.75). The watermarked image obtained for each SF has been exposed to eight image processing and geometric attacks that are-blurring, cropping, an addition of Gaussian and salt & pepper noise, resizing, rotation and sharpening as demonstrated in Figure7(a-h). To examine the effect of SF, two transform domain techniques DWT and RDWT with and without hybridization with SVD has been implemented.

Experiments have been performed to investigate the robustness and imperceptibility of the implemented algorithm in terms of CC (correlation), PSNR (Peak signal to noise ratio) and SSIM (Structural similarity index), where CC, PSNR, and SSIM are as specified below:

$$SSIM = [l(W,W*)]^{\alpha}.[c(W,W*)]^{\beta}.[s(W,W*)]^{\gamma} \quad (2)$$

$$CC \equiv \frac{\sum \left((W-\overline{W})(W*-\overline{W}*)\right)}{\sqrt{\sum (W-\overline{W})^2}\ \sqrt{\sum (W*-\overline{W}*)^2}} \quad (3)$$

$$PSNR = 10\log_{10}\frac{255^2}{MSE} \ \text{(dB)} \quad (4)$$

Where:

W is original watermark image

W* is the recovered watermark image

MSE is Mean Square Error

l, c, and s are luminance, contrast, and structure components respectively

Figure 7 depicts the effect of various image processing attacks as specified above on Lena image. The recovered watermark (W*) for all the algorithms have been presented in Figure8 (a-d). As SF indicates the amount of embedding watermark in the host image. The extent of embedding a watermark is variable for different types of images for attaining the desired imperceptibility. The robustness and imperceptibility of a digital watermarking system are dependent on the value of SF.

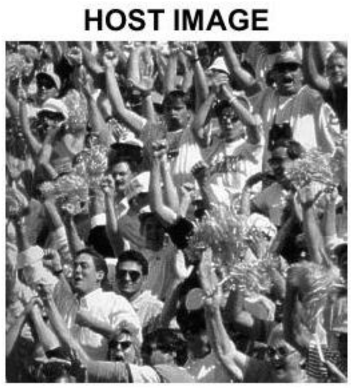
Robustness increases with increase in the value of SF but at the same time, imperceptibility reduces. Robustness has been measured by calculating two parameters CC and SSIM. The compilation results for CC(W, W*) and SSIM(W, W*) for different values of SF against different image processing attacks have been presented in Tables 1 and 2 for Lena and Crowd image respectively. The variation of SF for the above-specified transformation techniques has been depicted in the columns in the table and the applied image processing attacks have been shown in the rows. The first row in the tables depicts the attained values for a signed image with no attack imposed. It has been observed from the results in Table 1(a, b) and 2(a, b) that as the value of SF increases the corresponding value of NC and SSIM increases. The simulation results also show that there is less effect of image processing attacks with a higher value of SF that means we are better able to recover the watermark.

From the simulation results, it has also been observed that the robustness has improved when the transformation techniques are hybridized with SVD. A comparison of four popular transformation techniques specified above has also been shown in the tables. From the results, it has been observed that DWT-SVD outperforms rest of three techniques for all the attacks as well as without attack for all values of SF. Although RDWT-SVD provides better imperceptibility among all the three. In the Lena image, the value of SF=0.05 results in better PSNR for RDWT-SVD and DWT-SVD as 38.46dB and 31.45dB respectively. Also for the Crowd image, PSNR is better at SF=0.05 that is 32.43dB for RDWT-SVD and 28.14dB for DWT-SVD.

V. CONCLUSION

The effect of selecting a value of scaling factor on robustness and imperceptibility in robust watermarking techniques has been presented in this paper. For the empirical analysis, two widely used transformation techniques DWT and RDWT along with their hybridization with SVD has been taken into consideration. From the empirical analysis, it has been demonstrated that higher robustness and better imperceptibility can be achieved at different values of scaling factors. The PSNR is maximum at SF=0.05 whereas CC and SSIM increase with an increase in the value of SF, hence SSIM and CC are maximum at SF=0.75. Henceforth the watermarking problem can be considered as an optimization problem where an optimum solution for robustness and visual quality can be identified. Machine learning algorithms such as Genetic Algorithms, Artificial Neural Network Techniques with others can be used to resolve this optimization problem. This work also concludes that DWT-SVD provides better robustness as compared to DWT, RDWT, and RDWT-SVD. However, the data capacity is higher in case of RDWT and RDWT-SVD as the size of sub band gets reduced at each level of transformation in DWT whereas the size of sub bands remains same in the case of RDWT.

a. Lena Image



b. Crowd Image

c. Watermark

Fig.6. Standard grayscale images (a, b) Lena and Crowd (256x256 in .jpg format) as original host images (c) Watermark (binary image)

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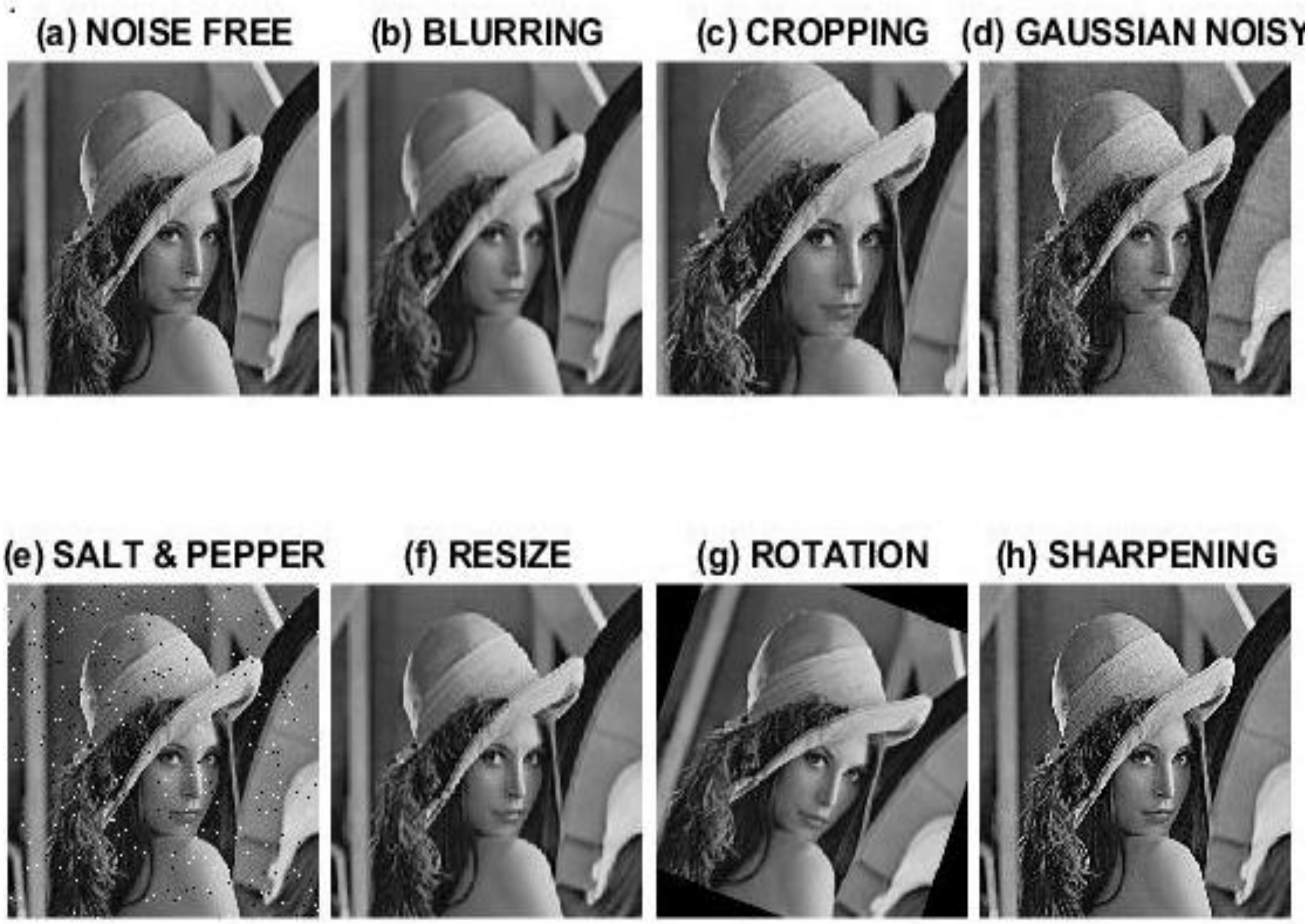
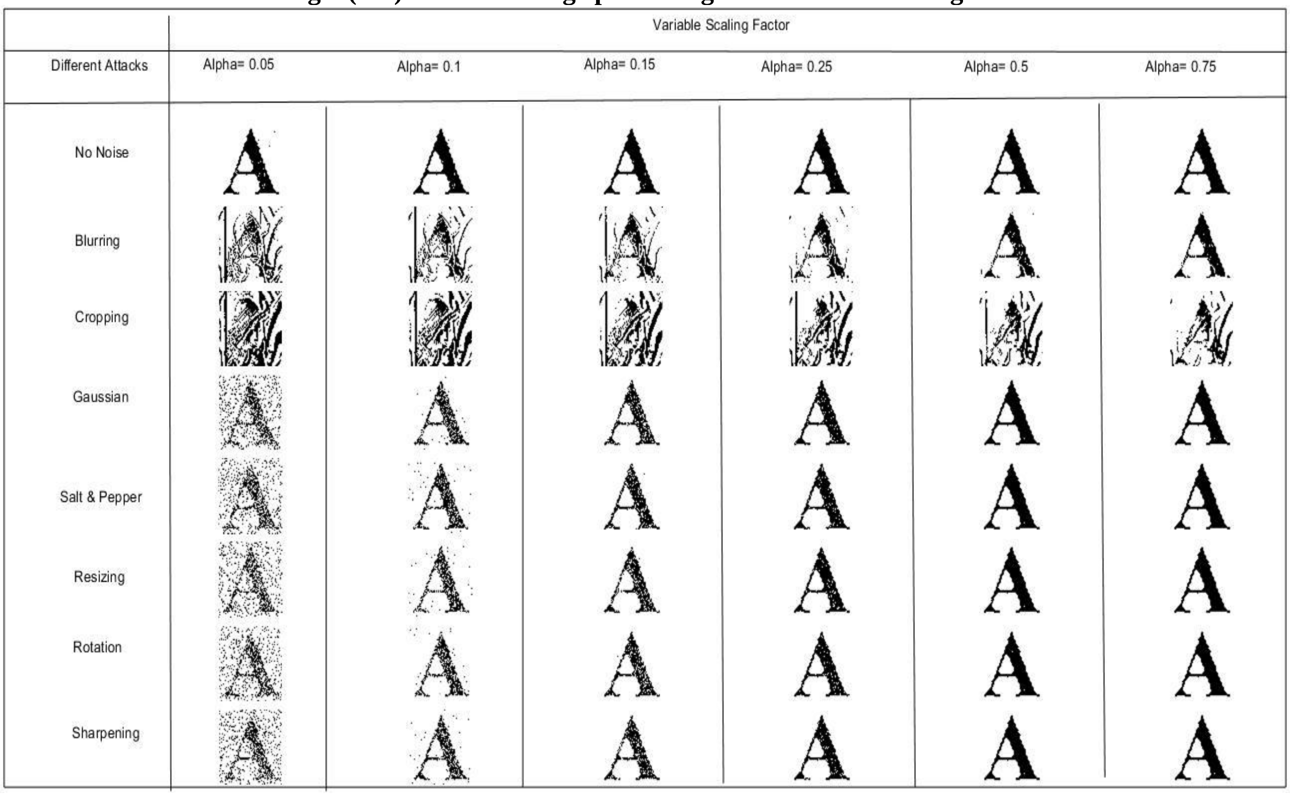
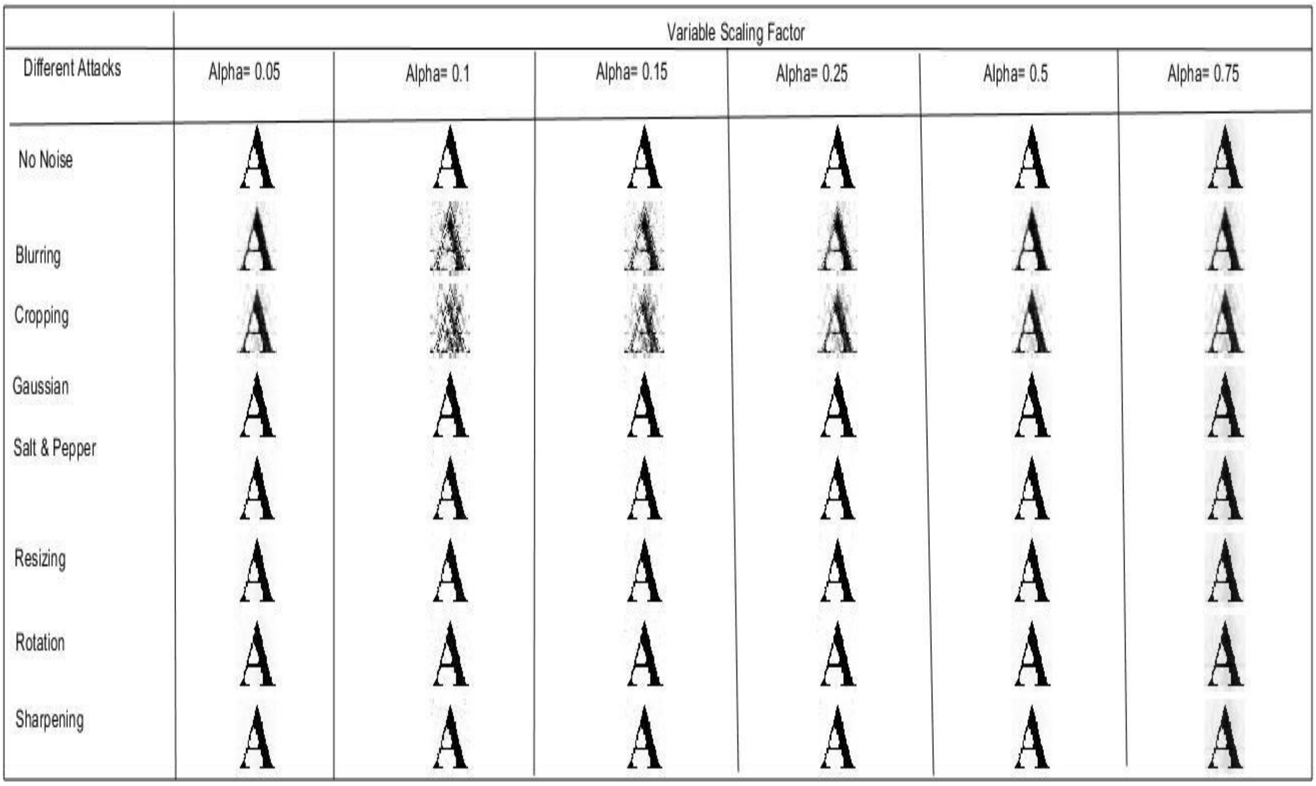


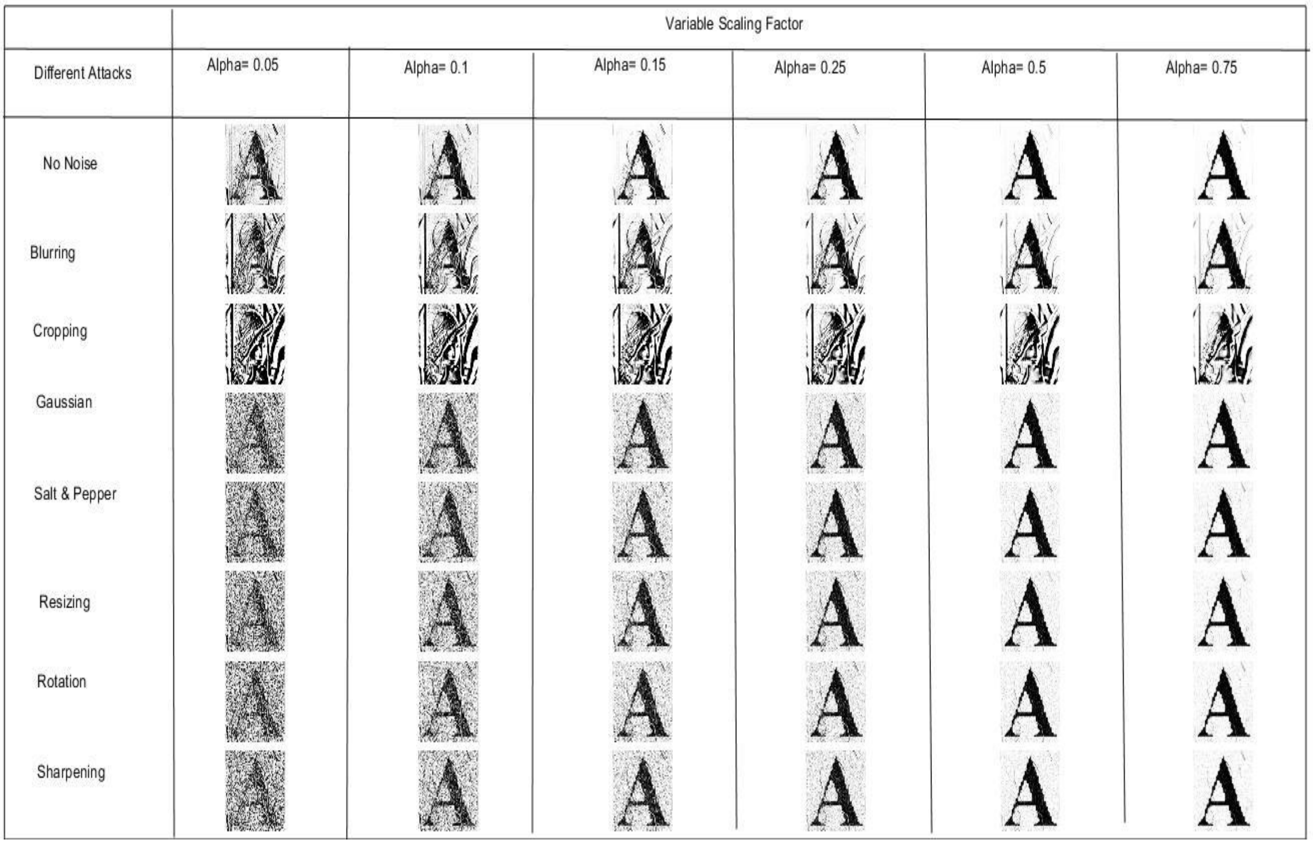
Fig. 7(a-h). Effect of image processing attacks on Lena image



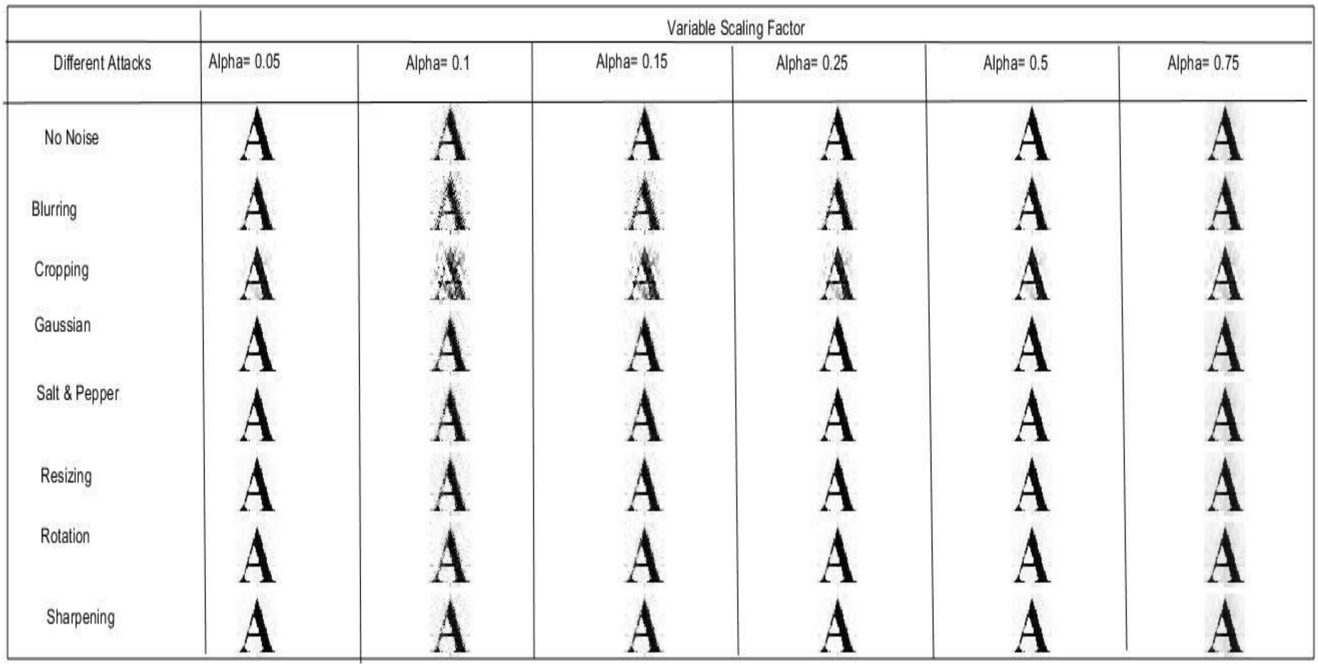
(a) Extracted watermarks from the attacked image Lena with corresponding to SF=0.05, 0.1, 0.15, 0.25, 0.5 and 0.75 by DWT scheme



(b) Extracted watermarks from the attacked image Lena with corresponding to SF=0.05, 0.1, 0.15, 0.25, 0.5 and 0.75 by DWT-SVD scheme



(c) Extracted watermarks from the attacked image Lena with corresponding to SF=0.05, 0.1, 0.15, 0.25, 0.5 and 0.75 by RDWT scheme



(d) Extracted watermarks from the attacked image Lena with corresponding to SF=0.05, 0.1, 0.15, 0.25, 0.5 and 0.75 by RDWT-SVD scheme

Fig. 8 (a-d). Extracted watermark image from the attacked image for different values of SF under DWT, DWT-SVD, RDWT, and RDWT-SVD schemes

Table 1(a-b) Correlation (CC) and SSIM (Structural Similarity Index) values of the extracted watermarks under various image processing attacks corresponding to different values of SF for Lena Image

(a) CC

Attacks	SF=0.05				SF=0.1				SF=0.15				SF=0.25				SF=0.5				SF=0.75			
	DWT	DWT-SVD	RDWT	RDWT-SVD	DWT	DWT-SVD	RDWT	RDWT-SVD	DWT	DWT-SVD	RDWT	RDWT-SVD	DWT	DWT-SVD	RDWT	RDWT-SVD	DWT	DWT-SVD	RDWT	RDWT-SVD	DWT	DWT-SVD	RDWT	RDWT-SVD
NO	0.989	1.000	0.606	0.687	0.996	1.000	0.772	0.859	0.998	1.000	0.869	0.917	0.999	1.000	0.927	0.960	1.000	1.000	0.972	0.983	0.999	0.997	0.980	0.984
BL	0.296	0.170	0.329	0.389	0.433	0.476	0.485	0.657	0.525	0.644	0.609	0.769	0.640	0.816	0.731	0.862	0.818	0.944	0.887	0.936	0.893	0.970	0.936	0.961
CR	0.092	0.043	0.079	0.259	0.146	0.351	0.130	0.655	0.202	0.613	0.187	0.818	0.267	0.841	0.251	0.921	0.383	0.950	0.370	0.971	0.470	0.956	0.453	0.970

SH	RO	RE	S&P	GN
0.506	0.520	0.518	0.484	0.511
0.993	0.993	0.994	0.995	0.993
0.268	0.269	0.272	0.263	0.278
0.703	0.700	0.716	0.692	0.709
0.826	0.828	0.831	0.766	0.838
0.998	0.999	0.999	0.997	0.999
0.525	0.519	0.528	0.469	0.529
0.883	0.891	0.887	0.888	0.887
0.942	0.942	0.947	0.879	0.946
0.999	0.999	1.000	0.999	0.999
0.729	0.734	0.738	0.647	0.736
0.942	0.944	0.942	0.940	0.941
0.977	0.979	0.978	0.953	0.978
1.000	1.000	1.000	1.000	1.000
0.874	0.872	0.871	0.810	0.874
0.975	0.974	0.976	0.975	0.976
0.995	0.995	0.995	0.988	0.995
1.000	1.000	1.000	1.000	1.000
0.959	0.960	0.960	0.931	0.960
0.988	0.988	0.987	0.988	0.988
0.997	0.997	0.997	0.993	0.997
0.996	0.996	0.995	0.995	0.996
0.974	0.975	0.975	0.960	0.975
0.984	0.984	0.984	0.984	0.984

NO: No Attack SH: Sharpening
BL: Blurring RO: Rotation
CR: Cropping RE: Resize
GN: Granular Noise S&P: Salt & Pepper

(b) SSIM

Attacks		NO	BL
SF=0.05	DWT	0.72	0.08
	DWT-SVD	0.95	0.08
	RDWT	0.09	0.07
	RDWT-SVD	0.32	0.20
SF=0.1	DWT	0.82	0.14
	DWT-SVD	0.97	0.06
	RDWT	0.16	0.11
	RDWT-SVD	0.48	0.32
SF=0.15	DWT	0.95	0.20
	DWT-SVD	0.99	0.19
	RDWT	0.38	0.21
	RDWT-SVD	0.59	0.41
SF=0.25	DWT	0.95	0.27
	DWT-SVD	1.00	0.40
	RDWT	0.43	0.26
	RDWT-SVD	0.70	0.52
SF=0.5	DWT	0.97	0.41
	DWT-SVD	0.96	0.67
	RDWT	0.61	0.41
	RDWT-SVD	0.77	0.66
SF=0.75	DWT	0.96	0.50
	DWT-SVD	0.85	0.77
	RDWT	0.70	0.50
	RDWT-SVD	0.74	0.72

SH	RO	RE	S&P	GN	CR
0.16	0.17	0.16	0.14	0.16	0.02
0.69	0.67	0.75	0.74	0.67	0.04
0.02	0.02	0.02	0.02	0.02	0.08
0.28	0.27	0.28	0.27	0.28	0.27
0.28	0.29	0.30	0.29	0.30	0.02
0.85	0.87	0.87	0.79	0.87	0.09
0.05	0.05	0.05	0.05	0.04	0.09
0.48	0.45	0.48	0.46	0.47	0.38
0.39	0.39	0.40	0.38	0.40	0.04
0.93	0.87	0.93	0.92	0.91	0.22
0.09	0.08	0.09	0.09	0.09	0.12
0.60	0.60	0.59	0.59	0.58	0.47
0.47	0.48	0.48	0.48	0.48	0.06
0.96	0.96	0.95	0.97	0.95	0.42
0.14	0.14	0.14	0.14	0.14	0.15
0.71	0.72	0.70	0.71	0.72	0.58
0.66	0.67	0.67	0.66	0.66	0.11
0.93	0.93	0.93	0.93	0.93	0.62
0.29	0.30	0.30	0.29	0.30	0.21
0.77	0.76	0.76	0.76	0.76	0.69
0.75	0.75	0.75	0.75	0.75	0.15
0.83	0.83	0.82	0.82	0.84	0.60
0.42	0.42	0.42	0.42	0.42	0.26
0.74	0.74	0.74	0.74	0.74	0.67

NO: No Attack　　SH: Sharpening
BL: Blurring　　RO: Rotation
CR: Cropping　　RE: Resize
GN: Granular Noise　　S&P: Salt & Pepper

Table 2(a-b) Correlation (CC) and SSIM (Structural Similarity Index) values of the extracted watermarks under various image processing attacks corresponding to different values of SF for Crowd Image

(a)SSIM

Attacks	
SF=0.05	**DWT**
	DWT-SVD
	RDWT
	RDWT-SVD
SF=0.1	**DWT**
	DWT-SVD
	RDWT
	RDWT-SVD
SF=0.15	**DWT**
	DWT-SVD
	RDWT
	RDWT-SVD
SF=0.25	**DWT**
	DWT-SVD
	RDWT
	RDWT-SVD
SF=0.5	**DWT**
	DWT-SVD
	RDWT
	RDWT-SVD
SF=0.75	**DWT**
	DWT-SVD
	RDWT
	RDWT-SVD

NO	BL	CR	GN	S&P	RE	RO	SH
0.94	0.03	0.03	0.50	0.48	0.49	0.49	0.49
0.99	0.17	0.12	0.96	0.96	0.97	0.96	0.96
0.20	0.10	0.03	0.15	0.15	0.15	0.15	0.15
0.30	0.17	0.29	0.27	0.24	0.27	0.27	0.25
0.97	0.11	0.05	0.79	0.74	0.79	0.80	0.80
1.00	0.05	0.11	0.99	0.99	0.99	0.99	0.99
0.37	0.19	0.05	0.31	0.28	0.30	0.30	0.31
0.58	0.34	0.48	0.54	0.55	0.53	0.54	0.55
0.98	0.18	0.07	0.92	0.86	0.92	0.92	0.91
1.00	0.23	0.23	0.99	0.99	0.99	0.99	0.99
0.54	0.28	0.07	0.47	0.43	0.48	0.48	0.48
0.70	0.51	0.61	0.67	0.67	0.68	0.67	0.67
0.98	0.31	0.11	0.95	0.93	0.95	0.96	0.95
1.00	0.47	0.41	0.99	0.99	0.99	0.99	0.99
0.71	0.42	0.11	0.66	0.60	0.66	0.66	0.66
0.79	0.69	0.75	0.78	0.78	0.78	0.78	0.77
1.00	0.57	0.20	0.96	0.95	0.96	0.96	0.96
1.00	0.74	0.61	0.98	0.98	0.98	0.98	0.98
0.87	0.65	0.19	0.85	0.80	0.85	0.85	0.85
0.87	0.84	0.84	0.86	0.86	0.86	0.86	0.86
0.98	0.71	0.29	0.95	0.95	0.95	0.95	0.95
1.00	0.85	0.69	0.97	0.97	0.97	0.97	0.97
0.90	0.77	0.26	0.89	0.86	0.89	0.89	0.89
0.88	0.90	0.86	0.87	0.88	0.87	0.87	0.87

NO: No Attack SH: Sharpening
BL: Blurring RO: Rotation
CR: Cropping RE: Resize
GN: Granular Noise S&P: Salt & Pepper

(b) SSIM

Attacks		NO
SF=0.05	DWT	0.525
	DWT-SVD	0.737
	RDWT	0.018
	RDWT-SVD	0.133
SF=0.1	DWT	0.624
	DWT-SVD	0.835
	RDWT	0.036
	RDWT-SVD	0.237
SF=0.15	DWT	0.72
	DWT-SVD	0.848
	RDWT	0.066
	RDWT-SVD	0.305
SF=0.25	DWT	0.726
	DWT-SVD	0.852
	RDWT	0.099
	RDWT-SVD	0.386
SF=0.5	DWT	0.8
	DWT-SVD	0.867
	RDWT	0.189
	RDWT-SVD	0.494
SF=0.75	DWT	0.844
	DWT-SVD	0.887
	RDWT	0.257
	RDWT-SVD	0.539

SH	RO	RE	S&P	GN	CR	BL
0.149	0.144	0.15	0.146	0.15	0.007	0.009
0.517	0.502	0.53	0.497	0.487	0.032	0.129
0.011	0.014	0.012	0.012	0.012	0.042	0.017
0.11	0.121	0.12	0.1	0.109	0.361	0.13
0.276	0.273	0.273	0.274	0.267	0.01	0.027
0.694	0.669	0.692	0.68	0.711	0.027	0.102
0.025	0.025	0.025	0.026	0.026	0.046	0.026
0.203	0.214	0.199	0.211	0.214	0.417	0.209
0.361	0.369	0.368	0.363	0.37	0.014	0.047
0.726	0.693	0.75	0.711	0.737	0.069	0.062
0.045	0.043	0.045	0.044	0.044	0.051	0.04
0.284	0.272	0.278	0.271	0.273	0.445	0.27
0.432	0.439	0.433	0.432	0.43	0.02	0.079
0.767	0.768	0.764	0.768	0.746	0.125	0.031
0.073	0.074	0.075	0.074	0.074	0.056	0.058
0.372	0.367	0.36	0.367	0.367	0.465	0.362
0.526	0.528	0.533	0.529	0.527	0.034	0.161
0.735	0.736	0.74	0.735	0.742	0.193	0.25
0.149	0.149	0.15	0.149	0.151	0.07	0.107
0.481	0.482	0.481	0.478	0.483	0.473	0.501
0.544	0.541	0.543	0.536	0.545	0.046	0.225
0.695	0.689	0.699	0.692	0.691	0.24	0.414
0.212	0.211	0.213	0.215	0.215	0.084	0.149
0.528	0.526	0.528	0.533	0.53	0.491	0.58

NO: No Attack SH: Sharpening
BL: Blurring RO: Rotation
CR: Cropping RE: Resize
GN: Granular Noise S&P: Salt & Pepper

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