Comparative Analysis of Different Spatial and Transform Domain based Image Watermarking Techniques

[1]Himanshu Verma, [2]Mr. Tarun Rathi, [3]Mr. Ashish Singh Chauhan

[1]Research Scholar, Deptt. of Electronics and Communication, Bhabha Institute of Technology, Kanpur, India

[2]Asstt. Professor, Deptt. of Electronics and Communication, Hindustan Institute of Technology and Management, Agra, India

[3]Asstt. Professor, Deptt. of Electronics and Communication, Bhabha Institute of Technology, Kanpur, India

Abstract— Digital image watermarking is used to resolve the problem of data security and copyright protection. This paper presents spatial domain and transform domain based digital watermarking algorithms. In this paper PSNR and robustness based comparison among different spatial and transform based algorithms is made. Here LSB based and correlation based methods in spatial domain watermarking and DCT based, DWT based and SVD based methods are implemented in transform domain watermarking. For comparison purpose host image and watermark image are kept same. Robustness and PSNR of different algorithms are evaluated against some image processing attacks. Experimental results show that among all these algorithms, SVD method increases the robustness, security and quality of watermark image.

Keywords— least significant bit(LSB); discrete cosine transform (DCT); discrete wavelet transform(DWT); Singular value decomposition (SVD); human visual system(HVS); pseudo random noise sequence (PN sequence); peak signal to noise ratio (PSNR); normalized correlation (NC)

I. INTRODUCTION

With more availability of computer, multimedia and internet technology the data communication has become very fast [1]. But these also create the problems of data security and copyright protection [2]. In order to protect the copy right related issues digital image watermarking is used [3]. Earlier algorithms of watermarking were having the problems like quality, security and robustness of extracted watermark. The new algorithms are being introduced to reduce the impact of these problems.

There are two domain of the watermarking algorithm. One is spatial domain in which data bits are inserted in to the host image directly. Problem with spatial domain watermarking is that watermark can easily be detected by computer analysis [2] or can be destroyed by using malicious attacks in the channel. So these algorithms are not robust and secure. Another domain watermarking is transform domain which is much better than the spatial one. In this the message bits are embedded after transforming the host image by using one of the transform based method like discrete Fourier transform(DFT), discrete cosine transform (DCT), discrete wavelet transform (DWT), and singular value decomposing (SVD) based algorithm. It is very tough to detect the hidden information from the watermarked image in transform based algorithm. If coefficients of large values are taken to embed the message bits than extracted watermark image would be more robust [2].

There are many features of digital image watermarking like security, capacity, imperceptibility, robustness etc. but there is a tradeoff between three features capacity, imperceptibility and robustness. In recent years much work has been done to find the best tradeoff between the capacity, imperceptibility and robustness [4]. SVD based algorithm or SVD based hybrid algorithm gives better features.

II. EVALUATION PARAMETERS

Peak signal to noise ratio represents the quality of the watermark image. Mean square error (MSE) is to be calculated to compute the PSNR between extracted and original watermark image [5]. PSNR and mean square error (MSE) can be expressed as follow

$$PSNR = 10 \times \log\left(\frac{255^2}{MSE}\right) \quad (1)$$

$$MSE = \frac{1}{M \times N} \sum_{i=1}^{N} \sum_{i=2}^{M} [I(i,j) - I^*(i,j)]^2 \quad (2)$$

Where I(i,j) and I*(i,j) respectively are the pixel values of original images and watermarked images. Image matrix size is denoted by MxN [6].

Robustness is the ability of the watermark image to preserve information even after different noise and malicious attacks [3]. This is measured by normalized correlation (NC) used for similarity measurement between the original watermark and extracted watermark. Normalized correlation (NC) can be expressed as follow.

$$NC = \frac{\sum_i w_i \, w_i^{\,2}}{\sum_i w_i^{\,2}} \quad (3)$$

Here W is the original watermark and W* is the extracted watermark. [6]. Bigger the NC value means better similarity between two images.

III. SPATIAL DOMAIN ALGORITHM

A. LSB based digital image watermarking

Least significant bit based watermarking is very earlier and simple method for information embedding [1, 7]. In this algorithm watermark image is changed in to bits and pixels of the host image are converted in to binary values. The least significant bits of the selected pixels of the host image are

replaced by the message bits. The message bits can be embedded in a sequence of pixels which acts as a secret key without knowing this one can not extract watermark from watermarked image. In the extraction part, the message bits are recovered from the host image and reshaped to generate watermark image [2, 7]. In this algorithm The LSBs of the host image are varying which contribute less in the watermarked image which means quality of the watermarked image is not affected much.

B. Correlation based digital image watermarking

This is considered as one of the best spatial domain watermarking methods in which two pseudo random noise (PN) sequences for message bit '1' and '0' are used. Using a gain factor These pseudo random noise sequences make a pattern W(x,y). Using these patterns watermarking mask is prepared which is of the same size of host image. This watermarking mask is added to the host image to produce watermarked image [7].

$$Im_w(x,y)=Im(x,y) + k.W(x,y) \quad (4)$$

Where

$Im_w(x,y)$=Watermarked image

Im(x,y) = Original image

K= Gain factor

W(x,y)= Watermarking mask made of PN sequence

Increasing k increases the robustness of the watermark at the expense of the quality of watermarked image. At the extraction algorithm the correlation between random noise and the image is found out and watermark is extracted [7].

IV. TRANSFORM DOMAIN ALGORITHM

C. DCT based digital image watermarking

This is a transform domain algorithm which is more robust than spatial domain method. A discrete cosine transform (DCT) converts the image in terms of a sum of cosine function oscillating at different frequencies [8]. In blind DCT watermarking the host image is segmented in to blocks of same size [9]. DCT based algorithm transforms every block in different coefficients. For single image embedding two mid frequency coefficients are modified because high frequency coefficients are more sensitive to different image processing attacks and low frequency coefficients are having problem of visual effect so mid frequency coefficients are selected for embedding the watermark message which improves the robustness of extracted watermark. Selected coefficients work as secret key at extracting algorithm. Without knowing this watermark extraction will not be possible. After modification in coefficients the inverse DCT is taken and combining all blocks produces the watermarked image [5].

D. DWT based digital image watermarking

There are many advantages of using discrete wavelet transform over DCT and other earlier transform based watermarking. At high compression ratio DCT produces blocking artifacts this problem is overcome using DWT algorithm. The DWT exploits the image in to spatial and frequency information and provides multi resolution description of the image. It separates an image into a lower resolution approximation image (LL) as well as horizontal (HL), vertical (LH), and diagonal (HH) detail components. It makes DWT as more accurate model aspects for human visual system (HVS) as compared to the FFT or DCT. Higher energy watermark can be embedded in the region which is less sensitive for HVS such as high resolution detail bands (HH, HL, and LH). This improves the robustness of the watermark without affecting the quality of watermark image [8].

To embed the watermark image first of all watermark image is converted in to bits. Host image is decomposed using the 1-level DWT algorithm into sub bands LL, LH, HL, and HH. Two PN sequence of the size of sub bands are taken. Using a gain factor these PN sequences are added with the LH and HL component. To get watermarked image we use inverse DWT operation. At the extraction algorithm same PN sequences are used which act as a secret key. From correlation between the PN sequence and watermarked image message bits are recovered and reshaped in to the watermark image [10].

E. SVD based digital image watermarking

Singular value decomposition is an algorithm to analyze the image matrix. It converts image in to three different metrics [11]. It is a kind of orthogonal transform used for matrix analysis. The SVD of image I_m can be describe as

$$I_m = HSV^T \quad (5)$$

$$I_m = [h_1 \quad h_2 \quad . \quad . \quad . \quad h_N] \begin{bmatrix} s_1 & & & & \\ & s_2 & & & \\ & & . & & \\ & & & . & \\ & & & & . \\ & & & & s_N \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ . \\ . \\ . \\ v_N \end{bmatrix}^T \quad (6)$$

I_m is the image matrix. H and V are two M×N and N×N unitary orthogonal matrices, and S is an N×N diagonal matrix [12]. Where the horizontal detail component of image I_m is represented by H matrix and vertical detail component of the image I_m is represented by V. Both V and H are orthogonal matrices and S is a singular matrix which consists of singular values. Singular values in S matrix are arranged diagonally and in decreasing order. One of the important properties of SVD is stability which means small variation in the singular values does not affect the watermark image [13]. This makes SVD algorithm much robust than other transform based algorithm.

After dividing the host image in to blocks, each block of host image is transformed using SVD. Singular values of singular diagonal matrix are modified according to the message bits. Two random sequences for two binary digits '1' and '0' are added to singular values with a gain factor. After modifying singular values we take inverse process of the SVD to generate watermarked image. At the extraction algorithm correlation between stored singular value and modified singular values are found. Using this, message bits are recovered and reshaped in to the watermark image.

V. EXPERIMENTAL RESULTS

In different watermarking algorithm (discussed above), variation in PSNR and robustness with respect of different noise and attacks are shown by the chart in Fig.1 and Fig.2 respectively. In spatial domain Correlation based method gives better watermark image than LSB based algorithm. Transform domain algorithms performs better than spatial domain. Noisy/Attacked watermarked images, extracted watermark images, and different parameters of different algorithms are shown in Table I, which shows that extracted watermark image from SVD based algorithm is of higher PSNR and better robustness among all performed algorithms.

.

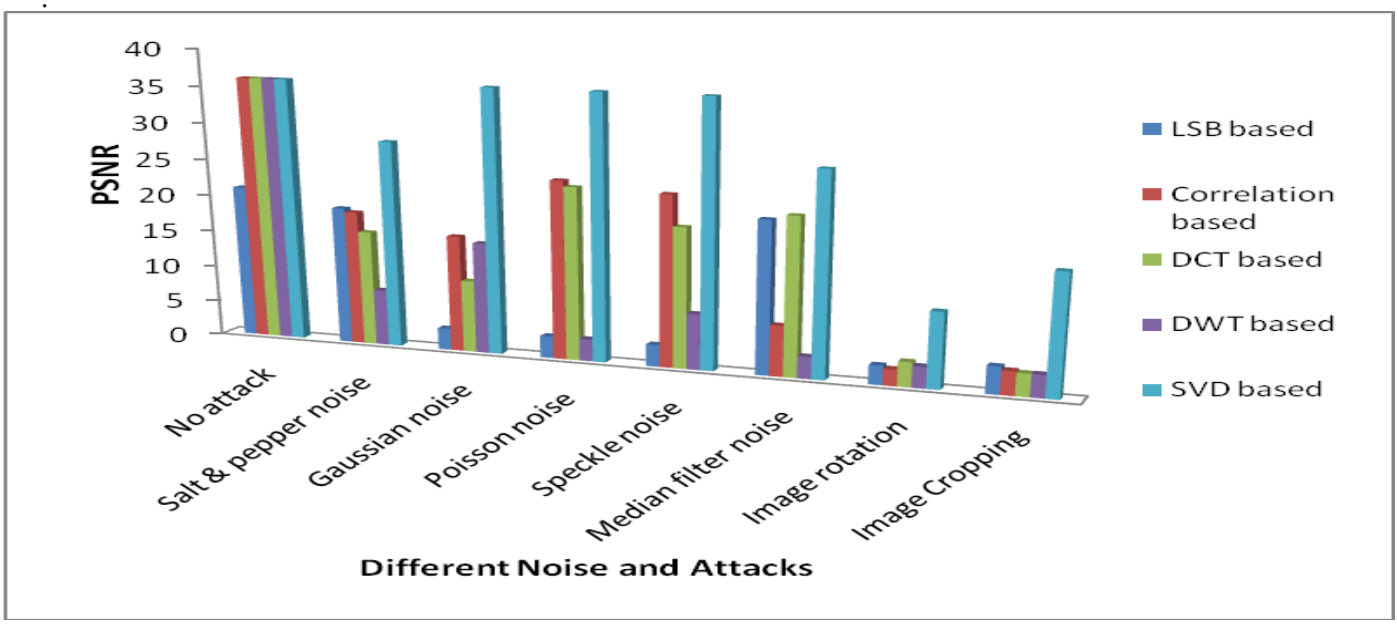


Fig.1: Variation in PSNR of watermark images in different watermarking algorithms with respect of different attacks

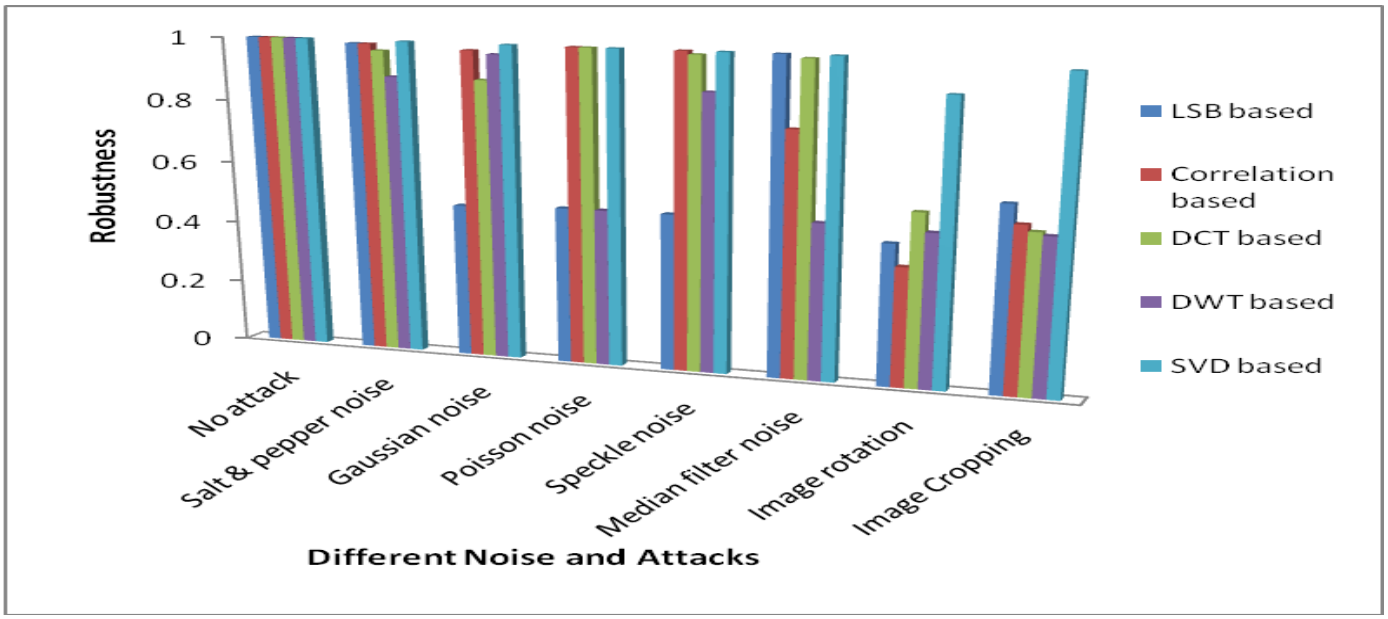
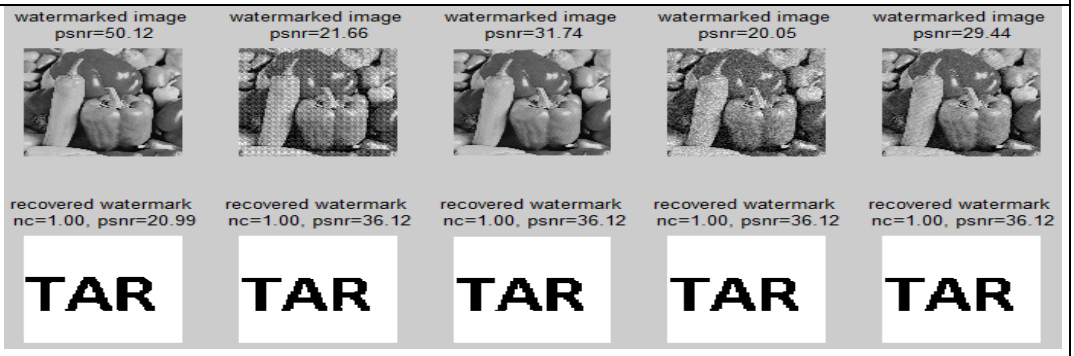
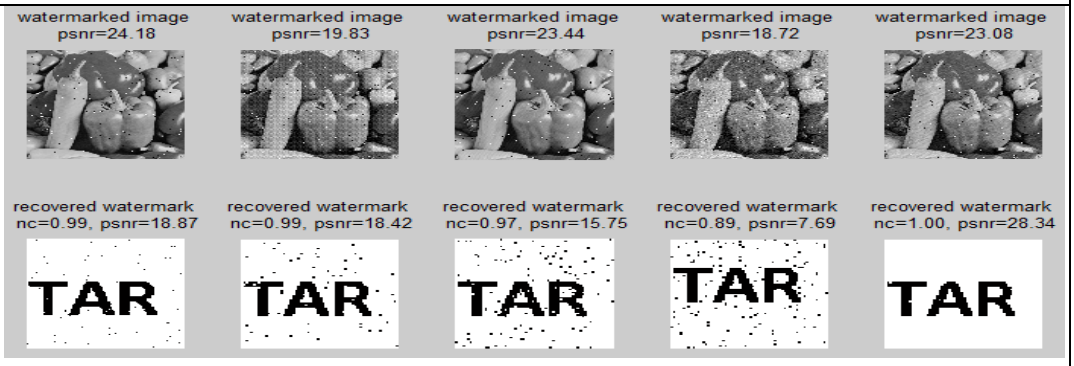
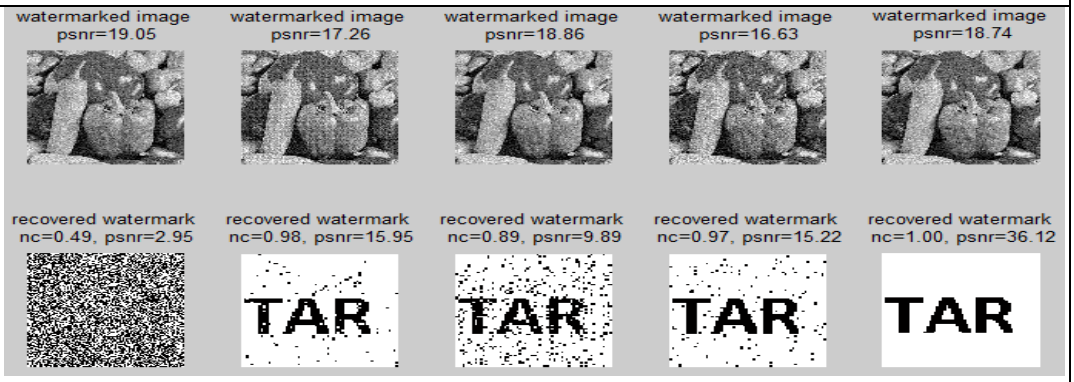
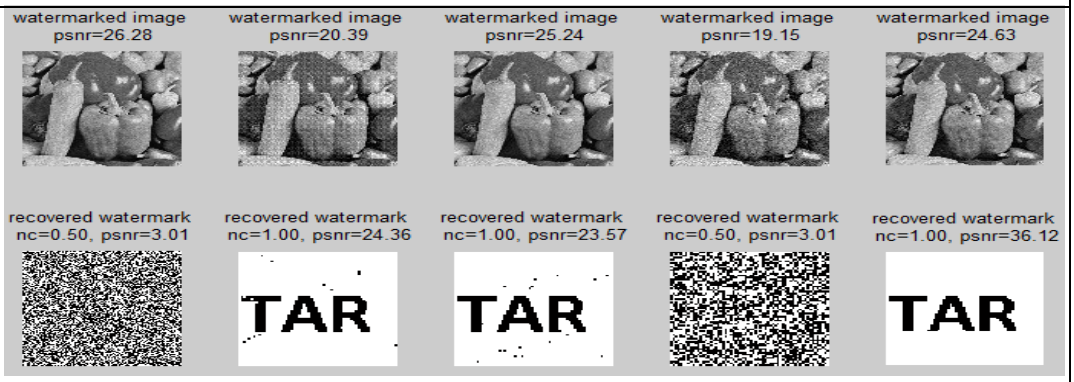
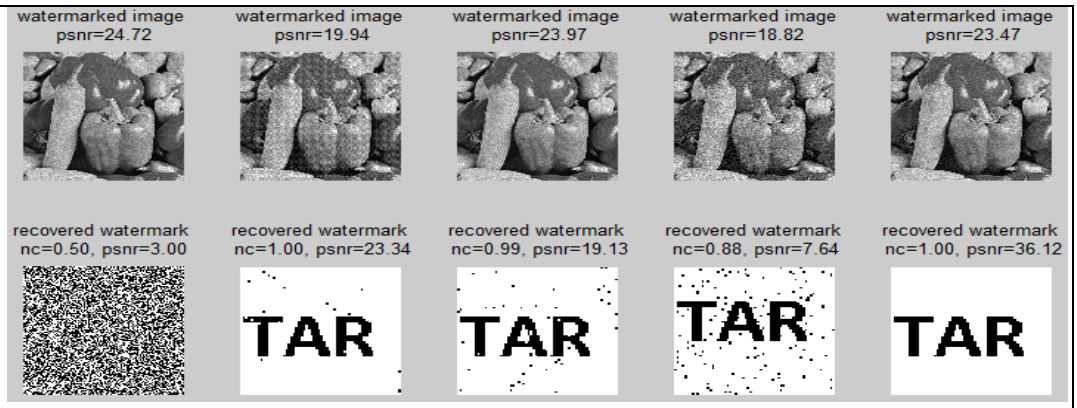
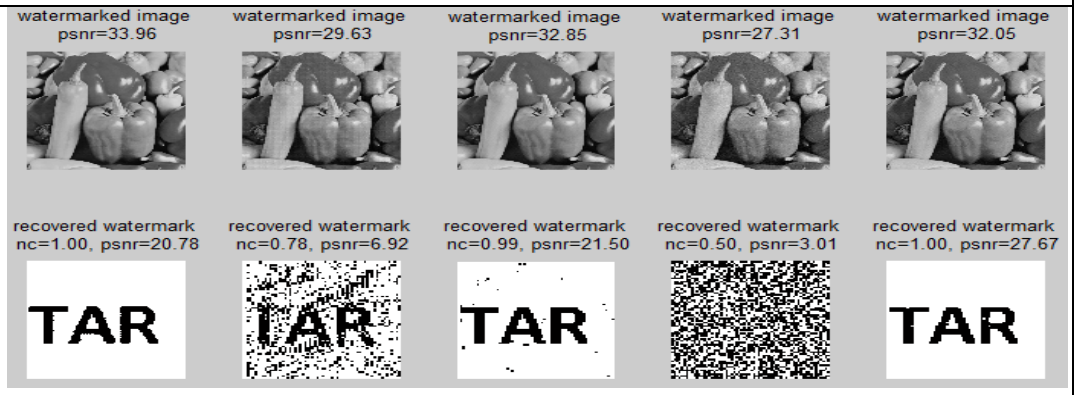
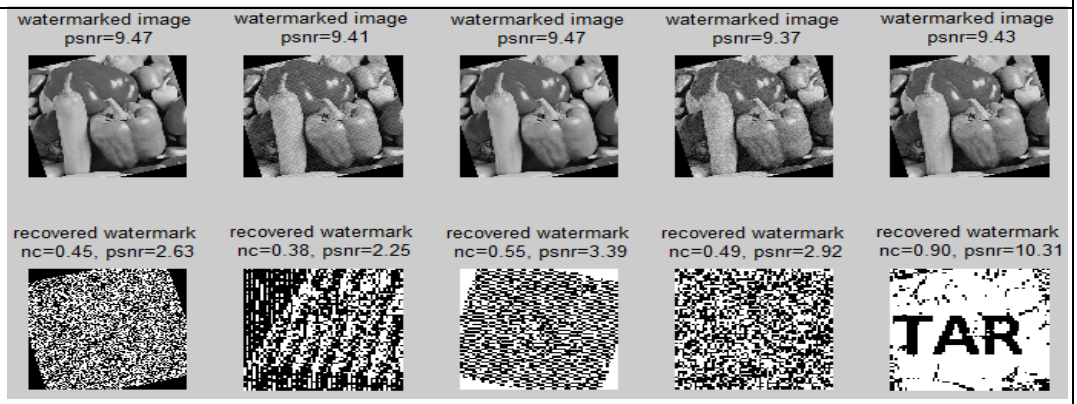
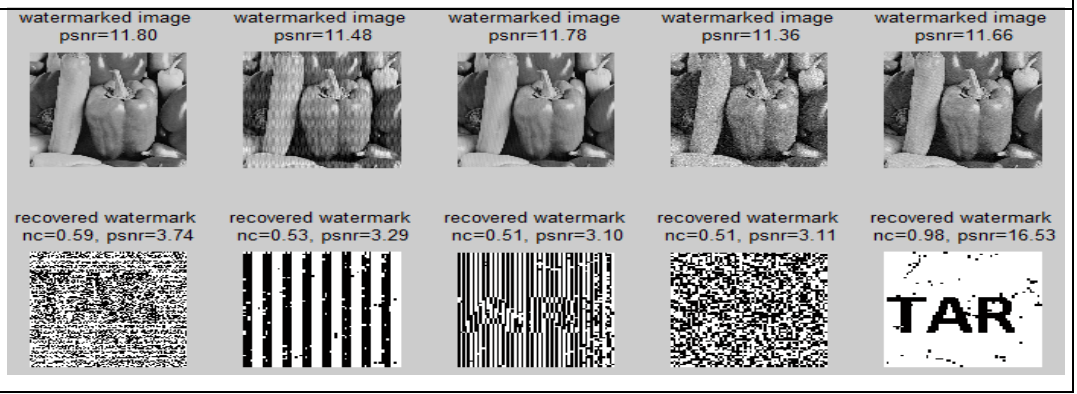


Fig.2: Variation in robustness of watermark images in different watermarking algorithms with respect of different attacks

Table I: Watermarks comparison from different watermarking methods

SN	Type of Noise/ Attack	LSB based	Correlation based	DCT based	DWT based	SVD based
1.	No attack					
2.	Salt & Pepper attack					
3.	Gaussian noise					
4.	Poisson noise					

5.	Speckle noise	
6.	Median filter noise	
7.	Image Rotation	
8.	Image cropping	

VI. CONCLUSIONS

In this paper, five algorithms of spatial domain and transform domain are implemented using MATLAB. For comparison purpose, host and watermark image are kept same for all algorithms. These algorithms are examined after inserting the different noise and attacks in watermarked image at extraction algorithm.

LSB performs well in case of Poisson and speckle attack which affects less in the watermarked image spatially. Correlation based technique does not impact on the visual quality if gain factor is kept small and noise pattern does not contain large values. This algorithm is more robust than LSB based algorithm against Gaussian noise, salt & pepper noise. But translation, rotation, scaling, cropping, median filter noise

affect the correlation values obtained and caused the watermark to be destroyed.

In transform domain algorithm the watermark bits are inserted after transforming the image using any of transform based algorithm. So noise and attacks affect less unlike spatial domain algorithm. In transform domain algorithms, DWT provides multi resolution description of an image and gives better result than DCT based algorithm without blocking artifacts.

SVD based algorithm extracts more robust and good quality watermark image than DCT, DWT based algorithm. In case of geometric attacks like image rotation and cropping SVD algorithm is able to extract watermark image unlike other algorithms. This is due to the stability, flipping and transpose etc properties of SVD. A hybrid algorithm using SVD and other transform based watermarking algorithm can also be used to extract much better watermark image.

VII. REFERENCES

[1] Ming, Ming Xiao; Liang Xuan Yu; Chuan Ju Liu " A Comparative Research of Robustness for Image Watermarking," IEEE international conference on Computer Science and Software Engineering, Page. 700 – 703, 2008.

[2] Gil-JeLee; Eun-Jun Yoon; Kee-YoungYoo, "A new LSB Based Digital Watermarking Scheme with Random Mapping Function", IEEE international conference on Ubiquitous Multimedia Computing, Page(s): 130 - 134 , 2008.

[3] Zhi Yuan An ; Haiyan Liu, " Research on Digital Watermarking Technology Based on LSB Algorithm, " IEEE Fourth International Conference on Computational and Information Sciences (ICCIS), , Page(s):207–210,2012

[4] Dehkordi, Amin Banitalebi; Esfahani, S.N.; Nasiri Avanaki, "Robust LSB Watermarking Optimized for Local Structural Similarity," 19th Iranian IEEE international conference on Electrical Engineering (ICEE), Page. 1 – 6, 2011.

[5] Majid Rafigh and Mohsen Ebrahimi Moghaddam, "A Robust Evolutionary Based Digital Image Watermarking Technique in DCT domain", Proc. of IEEE seventh International Conference on Computer Graphics, Imaging and Visualization, pp. 105-109, 2010.

[6] Wang Na, Wang Yunjin, Li Xia, "A Novel Robust Watermarking Algorithm Based On DWT And DCT", International Conference on Computational Intelligence and Security, Volume: 1, pp. 437 – 441, 2009.

[7] Singh, A. K.; Sharma, N.: Dave, M.; Mohan, A. "A Novel Technique for Digital Image Watermarking in Spatial Domain," 2nd IEEE International Conference on Parallel Distributed and Grid Commuting (PDGC), pp. 497 – 501, 2012.

[8] Vidyasagar M. Potdar, Song Han and Elizabeth Chang," A Survey of Digital Image Watermarking Techniques," in Proc. of the IEEE International Conference on Industrial Informatics, pp. 709-716, 2005.

[9] Quan, L. and Qing song,"A Combination of DCT Based and SVD Based Watermarking Scheme",Proceedings of 7th International Conference on Signal Processing (ICSP04), Vol. 1, pp.873-876, 2004.

[10] N. Kaewkamnerd and K.R. Rao, "Wavelet Based Image Adaptive Watermarking Scheme", IEEE Electronic Letters, vol. 36, pp.312-313, February 2000.

[11] R. Liu and T. Tan, "An SVD-based watermarking scheme for protecting rightful ownership," IEEE Trans. Multimedia., vol. 4, no. 1, pp. 121–128, Mar. 2002.

[12] Z.-M. Lu, H.-y' Zheng, and J.-w. Huang, "A Digital Watermarking Scheme Based on DCT and SVD," Proceeding of IIHMSP2007 Conference, Kaohsiung, pp. 241-244, November 2007.

[13] Chih-Chin Lai and Cheng-Chin Tsai,"Digital Image Watermarking Using Discrete Wavelet Transform and Singular Value Decomposition", IEEE Transaction on Instrumentation and Measurement, vol. 59, pp. 3060-3063, November 2010.