Comparative Study of SWT-SVD and DWT-SVD Digital Image Watermarking Technique

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ABSTRACT

Due to use of the latest computer technology in early days with wide available tools with various advance application, it is very easy for the unknown users to produce illegal copies of multimedia data which are floating across the Internet. To protect multimedia data such as images, videos,etc. on the Internet many techniques are available including various encryption techniques, steganography techniques, watermarking techniques and information hiding techniques. Digital watermarking is a technique in which a piece of digital information is embedded into a cover image and extracted later for ownership verification. Secret digital data which is hidden can be embedded either in spatial domain or in frequency domain of the cover data. in this paper frequency domain technique is used.by using singular value decomposition (SVD) with existing method DWT (Discrete Wavelet transform) that is DWT-SVD Combine watermarking technique and proposed method includes stationary wavelet transformation (SWT) with SVD that is SWT-SVD based water marking technique is proposed for hiding watermark. The quality of the watermarked image and extracted watermark is measured using peak signal to noise ratio (PSNR). A user defined or predefined watermark can be embedded within the image without disturbing quality of the image. It is observed that the quality of the watermarked image is maintained of proposed method results are tested for various attacks which include Salt and Pepper noise, Gaussian noise, cropping and compression,rotation etc. for both DWT and SWT for high. Robustness. A large payload can also be embedded in this proposed algorithm.SWT-SVD result PSNR is get improved as compare to DWT-SVD.In this paper Both the Methods are Implemented by Using MATLAB and Comparative Experimental Results are Reported.

Keywords

Watermarking, Stationary wavelet transformation (SWT), Singular Value Decomposition (SVD), Discrete Wavelet Transform (DWT), MSE (mean square error), PSNR (peak signal to noise ratio), large payload, Robustness

1. INTRODUCTION

In this paper, digital watermarking is process of an Embedding piece of code in digital data image and in the cover data image which is to be protected from duplication and extracted later for ownership verification in security aspects these are the main important applications of digital watermarking. The major point of digital watermarking is to find the balance among the aspects such as robustness to various attacks, security and invisibility. Property of Robustness and Fragility are important for ownership verification and image authentication respectively .in this paper by using DWT-SVD and SWT-SVD with the help of PSNR Values comparative analysis is done. SVD along with DWT is existing method and SVD along with SWT is the proposed method, after study analysis with different cover and logo images for both methods it founds that SWT-SVD gives better PSNR values result than DWT-SVD domain digital image watermarking. Theincreasing perceptibility will also decrease the quality ofwatermarked image. Generally watermark could not directly hidden, it is done by modifying the intensity value or pixel value of an image (spatial domain)or its frequency components. The former technique which is used for watermarking is spatial domain technique and frequency domaintechnique. After applying transforms it is converted into different sub components as HH, HL,LH, and LL, in which high frequency components HH are affected by most of the signal processing techniques such as lossy compression, so in order to increase the robustness,ideally the watermark is preferred to be placed in the low frequency components. But our human visual system is very sensitive to changes in low frequency range. So, i DWT-based watermarking techniques, the DWT coefficients LH,HL and HH are modified to watermark data. Because of the conflict between robustness and transparency, the modification is usually made in HL, LH and HH sub-bands to maintain better image quality as HH band contains finer details and contribute insignificantly towards signal energy. Hence, watermarking embedding in this region will not affect the perpetual fidelity of the cover image.By considering SWT-SVD combined full band watermarking is possible.in DWT-SVD technique to embed watermark image into the main or cover image, which proves robust to various kind of attacks which are mentioned as SWT helps to increase the payload i.e., large size watermark, which is an advantage over DWT-SVD techniques.In this paper with the help of PSNR Values[4] Comparative analysis is done. SWT-SVD gives better result than DWT-SVD domain digital image watermarking.

2. OWERVIEW OF DWT-SVD

2.1 DWT (Discrete Wavelet Transform)

The DWT decomposes input image into four components namely LL(low pass frequency) operation to the rows, LH(vertical high), HL(horizontal high) and HH(high pass frequency)Operation to the columns .which is shown in Fig.1.

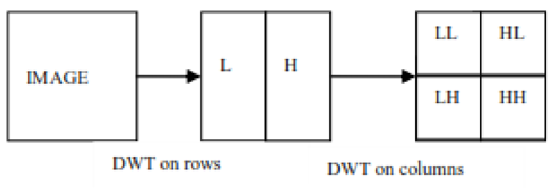


Fig 1. DWT Decomposition of Image

The lowest resolution level LL consists of the approximation part of the original image. The remaining three resolution levels consist of the detail parts and give the vertical high (LH), horizontal high (HL) and high (HH)frequencies. In the proposed algorithm, watermark is embedded into the host image (cover image) by modifying the coefficients of high-frequency bands i.e. HH sub-band. For a one level decomposition, the discrete two-dimensional wavelet transform of the image function f(x, y) can be written as

$$LL=[(f(x,y)*\emptyset(-x)\ \emptyset(-y))(2n,2m)]_{(n,m)\epsilon z^2}$$

$$LH=[(f(x,y)*\emptyset(-x)\psi\ (-y))(2n,2m)]_{(n,m)\epsilon z^2}$$

$$HL=[(f(x,y)*\psi(-x)\ \emptyset(-y))(2n,2m)]_{(n,m)\epsilon z^2}$$

$$LL=[(f(x,y)*\psi(-x)\ \emptyset(-y))(2n,2m)]_{(n,m)\epsilon z^2}$$

Where,$\phi(t)$ is a low pass scaling function and $\psi(t)$ is the associated band pass wavelet function.

2.2 SVD (singular value decomposition)

SVD is special matrix transform.it includes numbers with intrinsic characteristics. SVD provides excellent stability which prevents remarkable big changes due to small image disturbance hence SVD is widely used.SVD transform decomposes (SVD) is a factorization of a real or complex matrix, with many useful applications in signal processing and statistics. The singular value decomposition of an M×N real or complex matrix M is a factorization of the form as follows,

$$M = U\,\Sigma\,V^*$$

Where U is an M×M real or complex unitary matrix, ΣV is an M×N rectangular diagonal matrix with nonnegative real numbers on the diagonal, and V*is an N×N real or complex unity matrix. Any M×N (M≥N) real matrix A, can be written as, for (1≤i≤N),

$$A=USV^T = \sum_{i=1}^{N} S_i U_i V_i^T$$

Where U and V are orthogonal matrices, and S is an M×N

matrix with the diagonal elements Si representing the singular values of A. Ui is the ithcolumn vector of U,Vi is the ith column vector of V. Ui, Vi are called left and right singular vectors of A respectively. S has the structure of-

$$S= \begin{matrix} S1 \\ 0 \end{matrix}$$

$$S1= \begin{matrix} S1 & 0 & 0 & 0 \\ 0 & S2 & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & S8 \end{matrix}$$

To solve many mathematical problems in a linear algebra Singular value decomposition (SVD) tool technique is used. The theoretical background of SVD technique in image processing applications to be noticed is:

a) The SVs (Singular Values) of an image has very good stability, which means that when a small value is added to an image, this does not affect the quality with great variation.

b) SVD is able to efficiently represent the intrinsic algebraic properties of an image, where singular values correspond to the brightness of the image and singular vectors reflect geometry characteristics of the image.

c) An image matrix has many small singular values compared with the first singular value. Even ignoring these small singular values in the reconstruction of the image does not affect the quality of the reconstructed image with less loss.

So SVD technique can be applied to any kind of images. If it is a gray-scale image, the matrix values are considered as intensity values and it could be modified directly or changes could be done after transforming images into frequency domain. In SVD after applying transforms it decompose the given matrix into three matrices of same size using orthogonal transform, for decompose this matrix using SVD technique square matrix is always not needed.

2.3 DWT-SVD Watermarking Scheme

In this paper for comparative analysis three different input images and 3 different logo images are consider .the result of performance is given on the basis of PSNR values obtained.

Fig 2 gives block diagram of DWT-SVD watermarking.

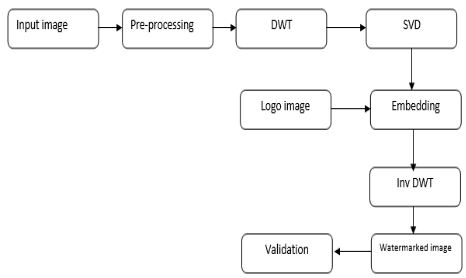


Fig.2 block diagram of DWT-SVD Watermark Embedding

1) In this by using existing method we decompose the cover image into 4sub-bands. It uses one level Haartransformation for decomposition of cover image A into 4 sub-bands.

2) After performing DWT, we perform SVD to eachsub-band images.

i.e, $A^K = U_a^K S_a^K V_a^{KT}$, k=1, 2, 3, 4

Where k denotes LL, LH, HL and HH sub-bands and $\lambda_i^{K,}$i=1, n denotes the singular values ofS_a^K.

3)In the same way, we apply SVD to watermark image,

i.e. $W = U_W\,S_W\,V_W^T$ where λ_{Wi}, i=1, n Denotes the singular values of Sw.

4) After this, we modify the singular values of cover image in each sub-band with the singular values of watermark image,

i.e.$\lambda i^{*K} = \lambda i^K + \alpha k \lambda wi$

where, i=1, n and k=1, 2, 3, 4.

5) So, we obtain 4 sets of modified DWT coefficients, i.e.
$A^{*K} = Ua^{K} Sa^{*K} Va^{KT}$ where k=1, 2, 3, 4
Obtain the watermarked image Aw by performing the IDWT using these 4 modified sub-bands.

Watermark extraction

1) First of all, we use one-level Haar Transform DWT to decompose watermarked (possibly distorted due to various kinds of attacks) image A*k into 4 sub-bands.

2)Then, we apply SVD to each sub-band, i.e.$A^{*K} = Ua^{K} Sa^{*K} Va^{KT}$ k=1, 2, 3, where k denotes the attacked sub-band.

3)Then, we extract the singular values from each sub-band, i.e.
$\lambda wi^{K} = (\lambda i^{*K} - \lambda i^{K})/\alpha k$ where i=1, …, n and k=1, 2, 3, 4.

4) Construct the four visual watermarks using the singular vectors, i.e.
$W^{K} = UwSwVw^{T}$k=1, 2, 3, 4

3. SWT

SWT (Stationary Wavelet transform): SWT is preferred as the wavelet transformation, since unlike the other wavelet transforms, the SWT procedures does not include any down sampling steps, instead, a null placing procedure is applied, Length as the original sequence. Instead, filters are modified at each level, by padding them with zeros as shown Fig.3

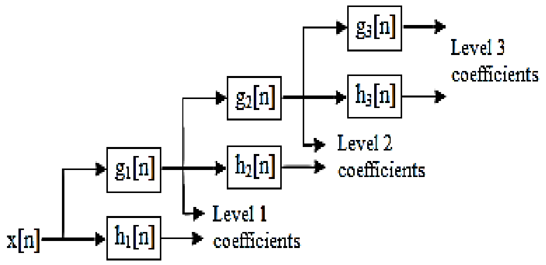


Fig.3.A 3 level SWT filter bank

3.1 Combine SWT-SVD

Embedding process

The block diagram for embedding watermark using SWT-SVD technique is shown in Figure 4.Original image transformed by SWT, which performs multilevel 2-D stationary wavelet decomposition and produces four 3-D arrays namely LL, LH, HL, and HH which contains the coefficients. Array HH, singular value decomposed and returns a vector of singular values. Similarly, the watermark is also gone through the same process. The watermarked image is obtained by applying ISWT to these coefficients.

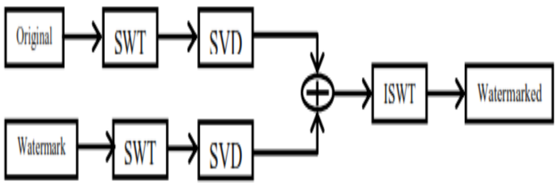


Fig 4.Watermark Embedding Process

- **Algorithm for embedding process**

Step 1: Stationary wavelet transformation technique applied to original host image, input is transformed into four 3-D arrays namely LL, LH, HL, HH.

Step 2: SVD technique is applied to high frequency component HH, and the result is a vector of singular values.

Step 3: Same procedure applied to watermark image also.

Step 4: Diagonal matrices of both cover image and watermark image are added with scaling factor.

Step 5: Inverse SWT applied to result to get the embedded watermarked image.

3.7.2 Extraction process

The block diagram for extracting watermark using SWT-SVD technique is shown in Figure 5 SWD- SVD, ISWT transformations applied in same order to get watermark from the watermarked image.

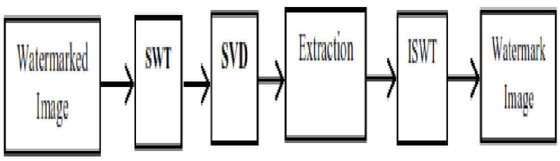


Fig.5.Watermark extraction process

- **Algorithm for extraction process**

Step 1: Stationary wavelet transformation technique is applied to watermarked image, input is transformed into four 3-D arrays namely LL, LH, HL, HH.
Step 2: SVD technique is applied to high frequency component HH, and the result is a vector of singular values.
Step 3: Watermark image components extracted from SVD transformed image by using same scaling factor.
Step 4: Inverse SWT applied to result to get the retrieved watermark image

4. FLOW DIAGRAM

Fig.6 Basic Flow SWT-SVD

Flow/Steps

Select cover image then Select logo image. Resize both the selected images. Convert to gray scale. Apply SWT and SVD.Embedding of Watermark then Extraction of watermark considering variousattacks Find, PSNR, MSE

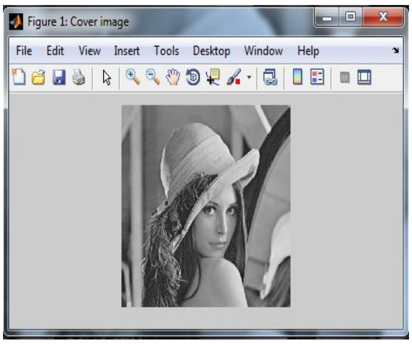
5. EXPERIMENTAL RESULTS

Considering lena image n logo image as input and cover image. The DWT-SVD and SWT-SVD both results are given bellow:

The magnitudes of the singular values for each sub-band of the Lena image are shown in the fig.7. Below Figure shows 512×512 gray scale cover image Lena, the 256 × 256 gray scale visual watermark copyright, the watermarked image, and the watermarks constructed from the four sub-bands. The scaling factor i.e. k for LL sub-band is taken to be 0.01 and 0.05 for other three sub-bands.Our implemented scheme is based on the idea of replacing singular values of the HH band with the singular values of watermark. In maximum and minimum singular values of all sub-bands of original image Lena are given by using matlab. The wavelet coefficients are found to have largest value in LL band and lowest for HH band.

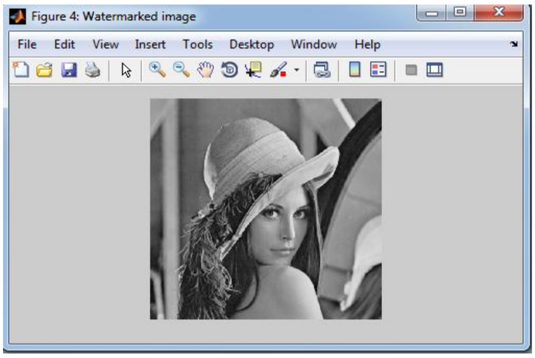
Basically in this work we created such a system that gives us proper results which done in the input image and for that we used different images and calculated the PSNR of this particular code using SWT –SVD and which precisely gives better results than DWT-SVD watermarking made. We used MATLAB software for coding purpose.

Case A) input lena image as cover image and logo image as watermark image the matlab results are as



1) Cover Image

2) Watermark Image



3) Watermarked Image

Table result .1 PSNR Values for DWT-SVD AND SWT-SVD FOR case A.

PSNR values for all 4 sub-band of extracted watermark image									
S.No	**Type of noise**	**PSNR LL**		**PSNR LH**		**PSNR HL**		**PSNR HH**	
		DWT	**SWT**	**DWT**	**SWT**	**DWT**	**SWT**	**DWT**	**SWT**
1	**Salt & Pepper noise**	**31.9321**	**36.6394**	**40.3748**	**48.596**	**39.987**	**50.9806**	**41.7604**	**51.7181**
2	**Rotation**	**26.8353**	**28.5646**	**27.2098**	**28.7096**	**27.2321**	**28.653**	**27.2154**	**28.7089**
3	**Median filter**	**32.1683**	**37.0913**	**40.4455**	**40.7622**	**40.4306**	**40.7575**	**42.0789**	**40.3722**
4	**Vertical Mirroring**	**31.0241**	**34.8345**	**39.3827**	**45.2476**	**40.5714**	**37.7302**	**43.8655**	**47.1083**
5	**Horizontal Mirroring**	**30.6356**	**34.2814**	**39.8627**	**36.778**	**37.3061**	**41.9602**	**42.5755**	**49.964**
6	**Gaussian noise**	**31.5608**	**34.4041**	**36.6099**	**41.3653**	**36.5327**	**39.845**	**38.1184**	**88.2612**
7	**Cropping**	**26.8253**	**26.1127**	**26.6542**	**26.0386**	**26.6485**	**26.0423**	**26.625**	**26.0417**
8	**Contrast**	**29.7217**	**30.396**	**28.9123**	**30.1187**	**28.8113**	**30.1426**	**28.8283**	**30.1325**
9	**Without noise**	**31.9458**	**36.476**	**40.4442**	**56.0751**	**40.0563**	**56.3885**	**41.9923**	**58.6528**

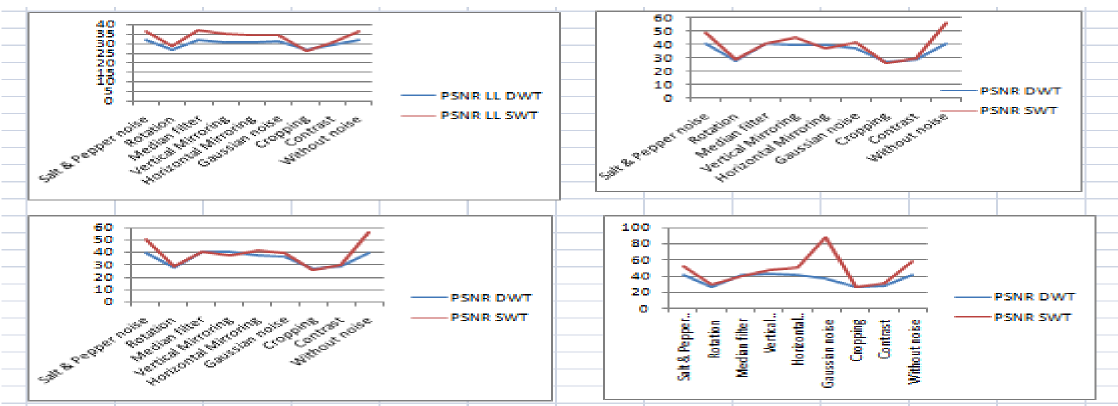
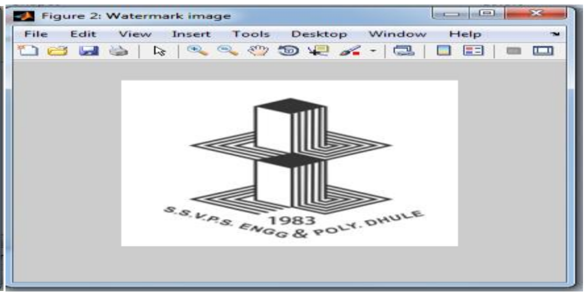


Fig.7Graphical results of PSNR for Case A.

Case B) Considering input Cameraman image as cover image and college logo image as watermark image MATLAB results are as bellow DWT-SVD and SWT-SVD both results are given bellow

1) cover image : Camerman image



2) watermark image : college logo

3) Watermarked image

Table result .2 PSNR Values for DWT-SVD AND SWT-SVD FOR case B.

PSNR values for all 4 sub-band of extracted watermark image									
S.No	**Type of noise**	**PSNR LL**		**PSNR LH**		**PSNR HL**		**PSNR HH**	
		DWT	**SWT**	**DWT**	**SWT**	**DWT**	**SWT**	**DWT**	**SWT**
1	Salt & Pepper noise	24.1483	28.66222	39.8564	46.7995	39.7349	43.9794	41.1972	43.3835
2	Rotation	22.2388	24.9992	24.5986	26.485	24.5925	26.1606	24.4917	26.1836
3	Median filter	24.1167	28.3469	37.4606	35.6765	37.4882	36.2419	38.3555	36.0218
4	Vertical Mirroring	23.2596	27.1764	40.7921	35.6728	38.7077	37.0817	48.0338	34.6178
5	Horizontal Mirroring	23.2226	27.1588	35.9818	35.0707	38.783	34.9363	37.8895	36.927
6	Gaussian noise	23.7055	27.7006	32.5145	34.9826	32.4129	34.6323	32.9466	34.2563
7	Cropping	28.2479	23.5558	23.5558	23.1082	24.4553	23.113	24.4077	23.1333
8	Contrast	23.5943	25.5813	25.5813	25.5823	23.4447	25	23.4366	25.0584
9	Without noise	24.1481	28.6703	28.67	45.0177	39.8255	45.8571	41.7627	43.5817

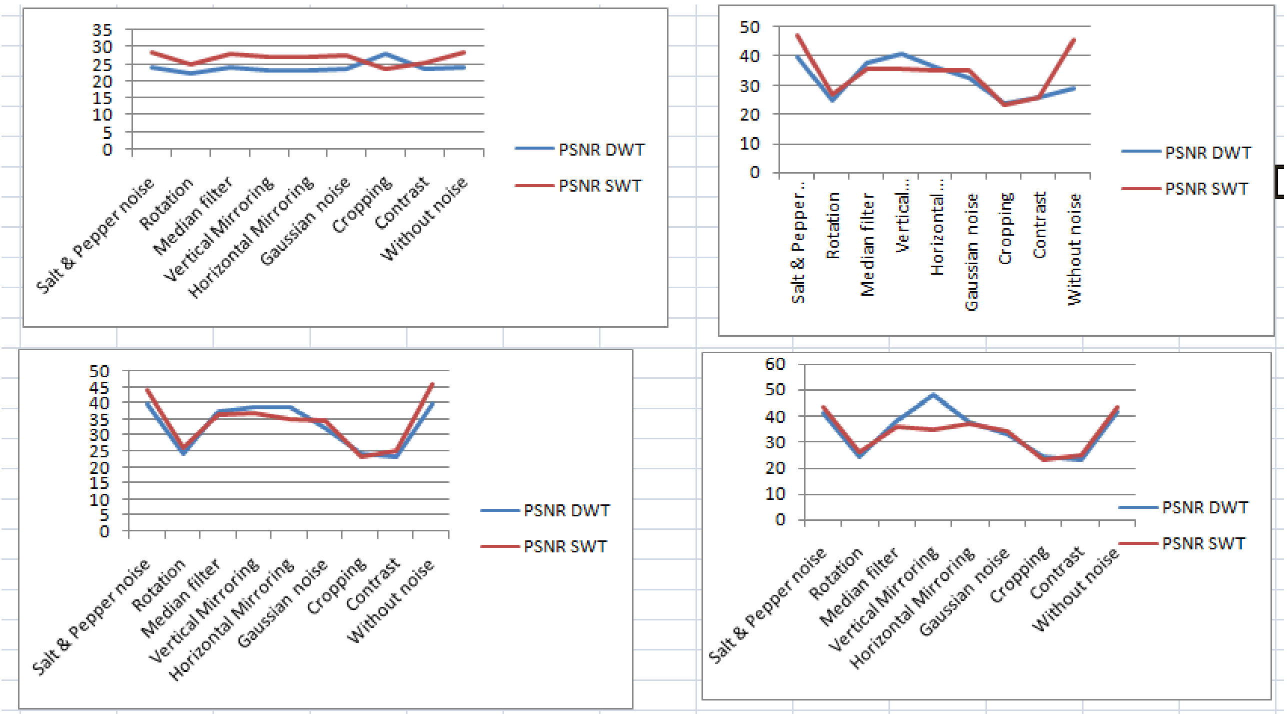
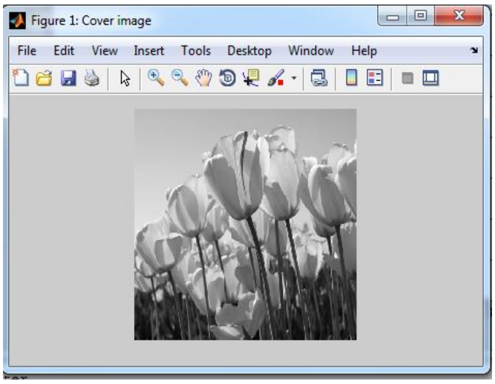
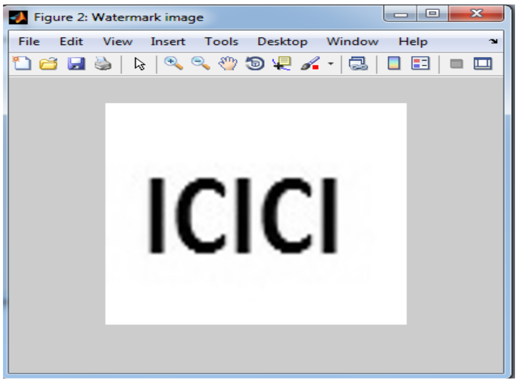


Fig.8 Graphical results of PSNR for Case B.

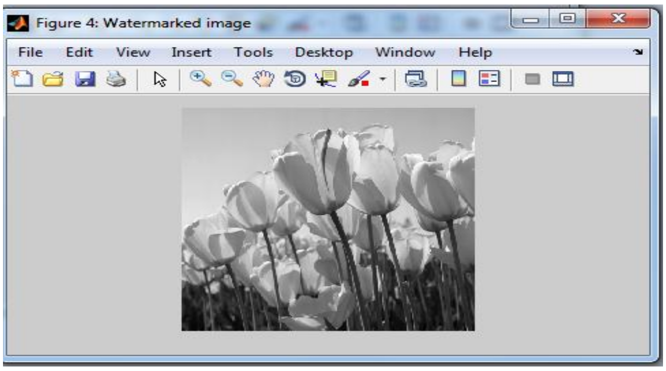
Case c) Considering input Tullips image as cover image and ICICI logo image as watermark image MATLAB results are as bellow DWT-SVD and SWT-SVD both results are given bellow



1) Cover image :



2) Watermark Image



3) Watermarked Image

Table Result .2 PSNR Values for DWT-SVD AND SWT-SVD FOR case C.

PSNR values for all 4 sub-band of extracted watermark image									
Sr.No	**Type of noise**	**PSNR LL**		**PSNR LH**		**PSNR HL**		**PSNR HH**	
		DWT	**SWT**	**DWT**	**SWT**	**DWT**	**SWT**	**DWT**	**SWT**
1	Salt & Pepper noise	24.0905	28.5703	40.9949	44.6078	40.6445	45.6057	42.1514	51.1027
2	Rotation	18.1427	19.6822	18.2784	19.7524	18.2787	19.7752	18.2783	19.7859
3	Median filter	24.1307	28.8865	40.6249	35.741	40.6727	35.7373	40.9241	36.6963
4	Vertical Mirroring	27.9684	29.8788	42.2937	28.4368	42.0517	38.3005	39.198	48.7411
5	Horizontal Mirroring	27.5232	30.0452	41.2452	30.3116	42.2849	42.3577	41.0419	36.2603
6	Gaussian noise	24.1542	28.5452	37.3221	39.3659	27.7957	37.5458	38.3349	39.2603
7	Cropping	30.6682	27.429	27.7942	24.9771	27.7957	25.0222	27.6592	25
8	Contrast	23.1538	24.6573	23.222	24.6767	23.2224	25	23.2026	24.6813
9	Without noise	24.0788	28.5853	40.5694	28.5853	40.5672	48.3511	42.1261	54.4602

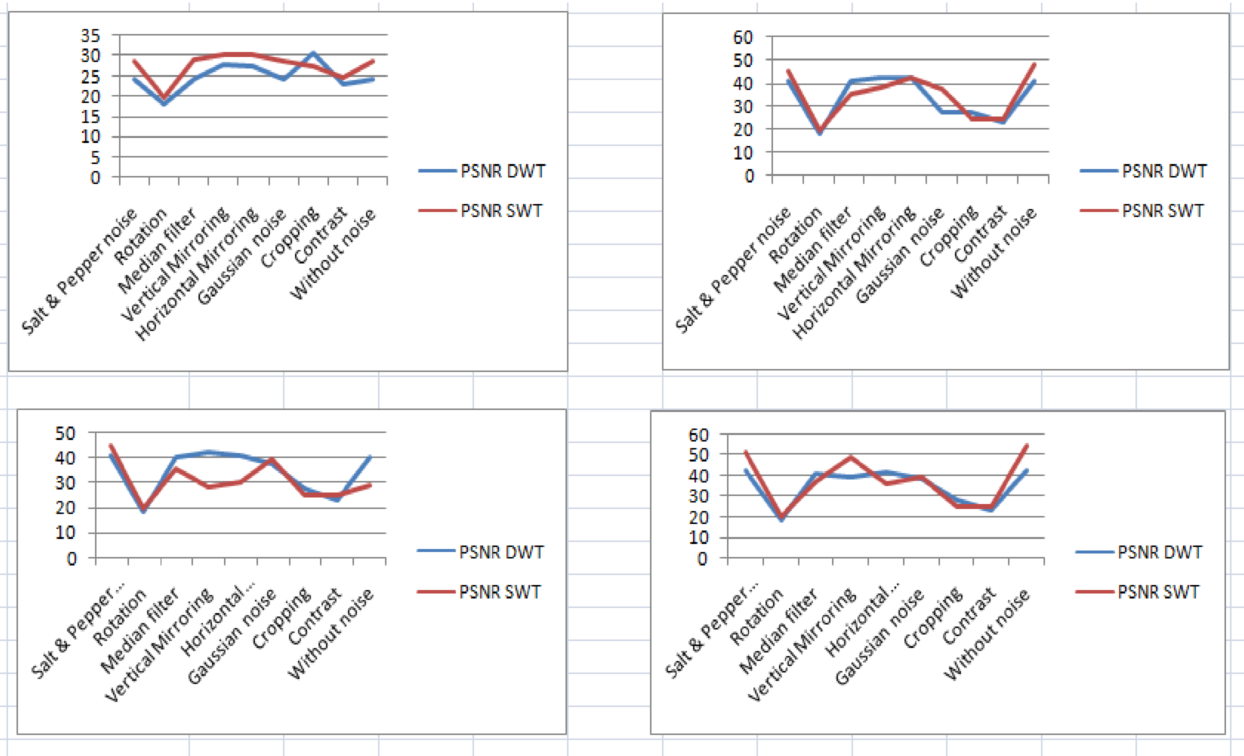


Fig.9 Graphical results of PSNR for Case C.

6. CONCLUSION

This paper present Digital image-watermarking technique based DWT-SVD and SWT-SVD where the watermark is embedded on the singular values of the cover image's SWT sub bands. The technique fully exploits the respective feature of these two transform domain method. Spatial frequency localization of SWT and SVD efficiently represents intrinsic algebraic properties of an image. Experiment results of the proposed technique have shown both the significant improvement in imperceptibility and the robustness under attacks quality of cover image is not degraded.by using SWT-SVD.In SWD-SVD large size Watermarks has been used. Experimental results shows related PSNR Values Which shows SWT-SVD is gives better result than DWT-SVD.

7. REFERENCES

[1] I.cox, J.killan,F.Leighton and T.shamoon,”secure spreadspectrum watermarking for Multimedia” IEEE Transactions on image processing ,vol.06,pp.1673-1687,1997

[2] D.Kundur and D.Hatzinakos,”A Robust Digital image watermarking method using wavelet based fusion”, proceeding of international conference on image processing, IEEE Vol.01, pp.544-5471998

[3] F.Bartolini , M.Barni,V.Cappellini and A.Piva ,”mask Building for perceptually Hiding frequency Embedded Watermarks”, Proceedings of international Conference on Image Processing , IEEE ,vol 01,pp 450-454,1999

[4] AsnaFurqan,Munish Kumar” Study and Analysis of Robust DWT-SVD Domain Based Digital Image Watermarking Technique Using MATLAB”IEEE, 2015 IEEE

[5] Dr.M.MohamedSathikand,S.S.Sujatha “Authentication of digital images by using Semi fragile watermarking Technique” vol 2pp 39-44,nov 2012

[6] Xiang Zhou., Duan X., and Wang D., “A Semi-fragile Watermark Scheme for Image Authentication”, IEEE International Conference on Multimedia modeling, pp.374-377 (2004).

[7] Mehmet UtkuCelik , Gaurav Sharma and Ahmet Murat Tekalp “Hierachical watermarking for secure image Authentication with Localization”Vol.11,pp 585-595,june 2002

[8] PrafulSaxena ,ShanonGarg and Arpita Srivastava “DWT-SVD Semi-Blind Image Watermarking Using High Frequency Band”April 28-29,2012

[9] Emir Ganic,AhmetM.Eskicioglu “Robust DWT-SVD Domain image watermarking :Embedding Data in all Frequencies”