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Medical Image Authentication by SWT and SVD

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Abstract*: *The proposed paper work is implemented using Stationary Wavelet Transformation (SWT) with Singular Value Decomposition (SVD).Even though, there are many other transformations, the Stationary Wavelet Transformation method is chosen for its shift invariance property. The designed method has three steps; the first step is the decomposing of the Medical image into sub-bands using SWT to find the value of sub band and as a second step is to apply SVD, third step will combine both the images with scaling factor. The experiments were conducted over gray scale of MRI and CT Medical images. The statistics of proposed method indicates that imperceptibility of Watermarked Medical images have a Peak Signal to Noise Ratio (PSNR) value of 50 DB for medical images. The robustness is ensured by having Correlation Coefficient (CC) of 1 for the retrieved watermark images. Security for the watermark is extended by encrypting the watermark with chaotic sequence.

Keywords*: *Medical image Authentication, Singular Value Decomposition, Stationary Wavelet Transformation, Scaling Factor.

I. INTRODUCTION

The major problem in today's transaction is the unauthorized accessibility to sensitive data by intruder. The digital data like audio, video and images can be easily accessed and shared with the help of the internet. To protect such data which is distributed the network; the copyright protection has come into existence [2][12].Digital Watermarking provides copyright protection for digital data. Image Watermarking methods are known to be of two types; Robust and Fragile water marking. The robust method resist for smaller modifications and the fragile watermarking fails even there is a small change in the input image. The use of transform domain namely; Discrete Fourier Transform, Discrete Cosine Transform (DCT), Stationary Wavelet Transform (SWT), Discrete Wavelet Transform (DWT).SWT are more beneficial than using spatial domain for watermarking.

The various applications of Digital Watermarking are Military applications, Medical Assistance, Copyright Protection, Fingerprint Authentication, Broadcast Monitoring etc. Transmission of Medical images over the internet is necessary for better diagnosis of patients. If such images are corrupted or modified by someone, may lead to various deviations and cause serious health issues.Nikhil[1] suggested SWT based SVD watermarking for color images with higher PSNR values in Red, Green and Blue planes separately. Nagarjuna[4] has proposed watermarking technique in stationary wavelet domain. The SWT has been used to avoid down sampling procedure. The algorithm calculates mean value of low frequency components for watermarking as threshold and set the watermarking a bit based on threshold value. The performance had been verified with Gaussian and Salt and Pepper noise. Khalid [5] has proposed SWT and DCT watermarking method for color images at low bandwidth in Discrete Stationary Wavelet Transform (DSWT) using Discrete Cosine Transform (DCT) domain. This approach separates three colors in the initial step. Apply DCT on each color after separation. Embed the watermark into Low frequency coefficient. The PSNR and CC values of Red, Green and Blue planes are calculated separately. Jaypal [7] had given Color Image Fusion in DWT domain with Sub-band exchange to enhance the security. The technique relies on exchanging the horizontal and vertical sub-bands of images with random swapping of chrominance components in the image, provides high resonance. Naina [11] stated sub-band fusion for Compressed and Uncompressed Digital Images based on SWT and SVD. Low band coefficients are chosen for watermarking and compare the results with compression and without compression. Yatindra [15] has given a method for medical images by Single level SWT and SVD with scaling vector between 0 and 1. O. Jane [19] suggested a Non-Blind Watermarking technique based on DWT and SVD. Quality of the watermarked image in embedding and after extraction can be improved by selecting the scaling factor larger than 1 and the proposed method is robust against several types of attacks. Heena [20] advised Discrete Wavelet Transform that is based on scaling factor watermarking technique high frequency band of wavelet transformation domain. The simulation results in good perceptual quality of the image. Imane [22] suggested SWT and Fast Walsh-Hadamard Transform (FWHT) technique for image authentication with the watermark image is inserted into the high frequency high sub-band of the original image. FHMT offers speediness in the calculation of coefficients. This method is tested against various degrees of Rotation, Compression attack parameters. Vaidya et al.[23] has proposed the concept of game theory in watermarking scheme using DWT.

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II. BASIC CONCEPTS

A. Stationary Wavelet Transformation (SWT)

Stationary wavelet transform (SWT) is approach with inherently redundant scheme.

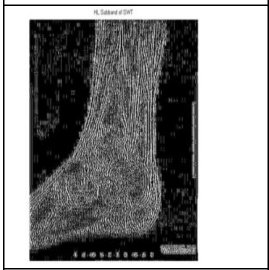
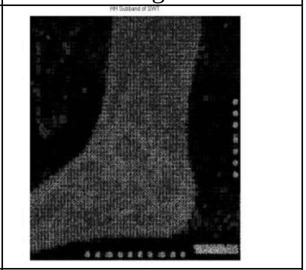
	
Low-Low band	Low-High band
	
High-Low band	High-High band

Table I: Decomposition of the Medical image into four components (Negative form of LL sub–image) after applying SWT.

The single level 2D stationary wavelet transform separates the image into four sub-band images low and high respectively. Each sub image the same size as the original image. The approximation of an image can be noticed in Low band (LL).The result of applying SWT transformation for the input image can be seen in Table I. Note that the low band sub image is negated to have a better visual quality.

B. Singular Value Decomposition (SVD)

SVD is a good mathematical tool in linear algebra. SVD can be used in Image and signal processing with less computation cost. Factorization of real or complex matrix results in singular value decomposition (SVD) [13].The observed fact is modifying U and V component of SVD will be less affected with distortion and recovery of an image can be achieved easily. It can be used in Medical images and is the most resistant against possible attacks. SVD is matrix factorizations given by equation. (1). If A is an M×N matrix, then A is a product of three factors:

$$A = UDV^T \quad (1)$$

U is an orthogonal M×M matrix, V is an orthogonal N×N matrix, V^T is the transpose of V, and D is an M×N matrix that has all zeros except for its diagonal entries, which are non-negative real numbers.

III. PROPOSED METHOD

The suggested method is Non-blind image watermarking for securing medical images using SWT and SVD. The medical image is incorporated into watermark to get watermarked image. For the implementation, two levels of SWT with HH sub band are used. In the next step SVD is used for decomposition. The same method is applied to watermark for singular matrix. The singular value of the host medical image and the watermark image are added and then inserted back into the selected host band by apply inverse SWT to obtain the watermarked image.

A. Process of Embedding

The process is carried out with second level of SWT. The proposed method chooses high band (HH), since changes in the edge coefficients does affect less on the visual quality of the image. Apply SVD to these sub bands to provide more robustness to the authentication. The above procedure is repeated for the Watermark Image and embedding both the Medical image and Watermark Image with the Scaling Factor. As a final step find the inverse of the transformation for the watermarked image as shown in Fig.1.

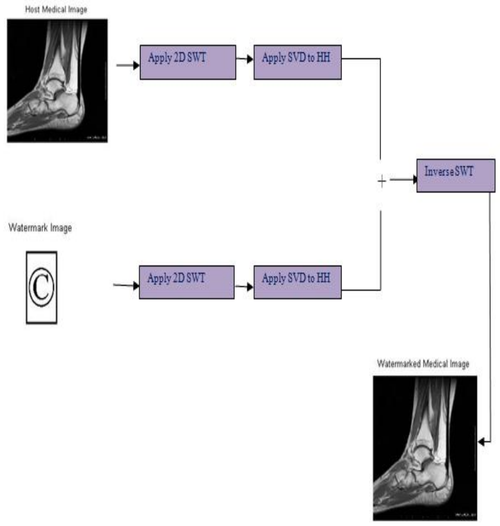


Fig.1. Process of embedding.

B. Process of Extraction

This process is performed for the extraction of watermark image and to check the authentication of the medical image. The process is carried out using watermarked medical image with original medical image. The transformation is applied to watermarked and original medical images to get the high bands (HH).SVD is applied to these high bands and retrieve Watermark Images using the scaling factor 5. As a final step find the inverse of the transformation to get the watermark image as in Fig.2.

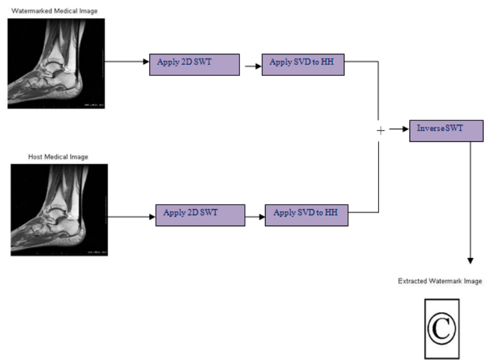


Fig.2. Process of extraction

IV. EXPERIMENTAL RESULTS

The suggested method was tested on various CT and MRI images of different age and gender. Watermark and medical image are of the same size to preserve the integrity of the system. Size of medical and watermark images are 512X512 pixels. The MATLAB 2013a software is used for the implementation. The proposed technique has been evaluated using PSNR and CC .The experiment is conducted over 100 CT and MRI images. The PSNR is obtained with Equation. (2), where Mean Square Error (MSE) between host and watermarked medical images.

$$PSNR = 10\log_{10}\frac{255X255}{MSE} \quad (2)$$

Equation.(3), represents CC is calculated between original and extracted watermark images.

$$CC = \frac{\sum_{i=1}^{n}(x_i-\overline{x})(y_i-\overline{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\overline{x})^2(y_i-\overline{y})^2}} \quad (3)$$

The experiment has been conducted for 100 medical images by considering different scaling factors in Fig.3.

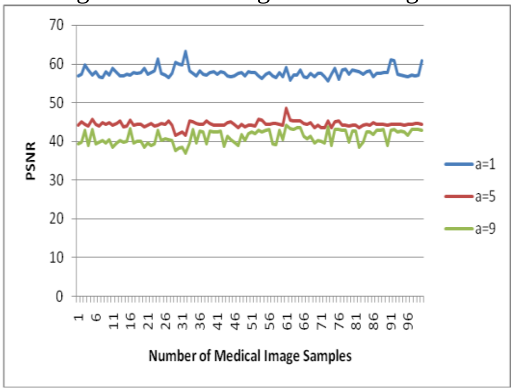


Fig.3. Bar graph of PSNR for different scaling factor applied for medical images

The maximum PSNR can be obtained with the scaling factor 1,5,9 are 47,25 DB, 42.13 DB and 41.77 DB respectively.PSNR value achieved is high with a=1and will be decreased with increase in the scaling factor.

The experiment is extended to check the imperceptibility and robustness by using below sample images as in Table II. The algorithm has been tested with various attacks for the above medical images. Table III. Represent the values of PSNR and CC for the sample images of Table II. Table III (A) indicates the value of PSNR and CC without applying attacks for the watermarked medical image as 51 DB and 0.9943. Table III. (B) depicts effect of Salt and Pepper noise with 5 percent, the PSNR is decreased to 30 DB and CC value is equivalent to 0.93.

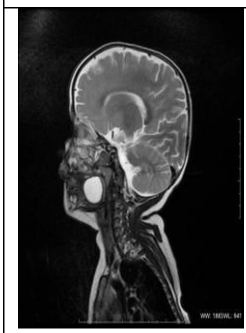
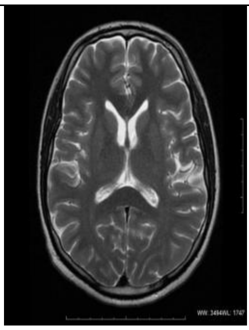
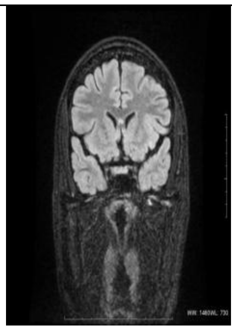
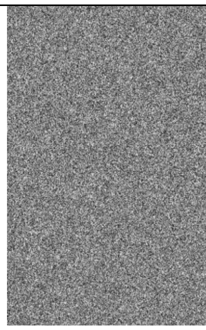
Image 1	Image 2	Image 3	Image 4	Encrypted watermark
				

Table II. Sample Medical Images

Index	PSNR	CC	PSNR	CC	PSNR	CC	PSNR	CC
A	51.3593	0.9943	50.1769	0.9877	48.1831	0.99	55.0837	0.9886
B	30.48	0.9353	29.9075	0.9348	20.9724	0.9364	30.0647	0.9357
C	31.16	0.9328	30.4329	0.9323	30.4939	0.9338	30.8035	0.9326
D	30.7116	0.9176	30.1614	0.9178	30.2116	0.9185	30.3322	0.9174
E	30.4473	0.9354	29.8992	0.9348	29.9759	0.9366	30.0695	0.9351
F	30.3728	0.9342	29.8365	0.9336	29.9423	0.9352	29.9971	0.9339

Table III. PSNR and CC values

Table III (C) represents adding gaussian noise with 0 mean and 0.05variance. PSNR value is 30 DB after applying gaussian noise to the image and CC is 0.93.Table III (D) depicts the effect of median filter of 3X3 attacks with PSNR value of 30 DB and 0.91 in CC. Table III (E) depicts addition of poisson noise. The result of this noise is 30 DB and 0.91 in PSNR and CC value accordingly. Table III (F) indicates value of PSNR and CC after adding 5 percent of speckle noise to the watermarked image as 30 DB and 0.93.

Table. IV shows the sub-image performances when we apply the proposed method to these bands. Table IV a represents the host image and watermark image used.

Table IV a Host image and watermark image

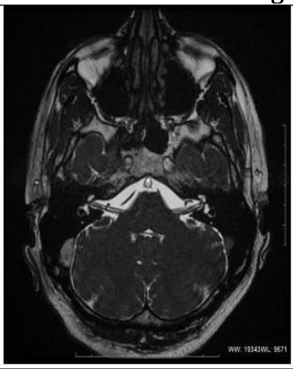
	
Host Image	Watermark Image

Table. IV b Shows the various Sub-Image performances when we apply the proposed method to these bands. The observations from the Table 4 can be listed as below.

1. Low Band (LL) provides PSNR of 30 DB since the important coefficients present in this region, but the visual quality of medical image is poor and cannot be used for authentication of medical images. CC of Watermark 0.8206 indicates the original and recovered watermark images are less correlated.

2. Vertical and Horizontal Sub-bands(LH and HL) are good for watermarking visual quality as Watermarked Medical Image is acceptable with an average PSNR of 49 DB and CC value is 0.9992 represents the Original and Recovered Watermark Images are well correlated.

3. Diagonal Sub-Band (HH) provides a high PSNR of 51 DB and CC Value is 0.99 represents the watermarked medical image is imperceptible and acceptable with high correlation in the original and recovered watermark

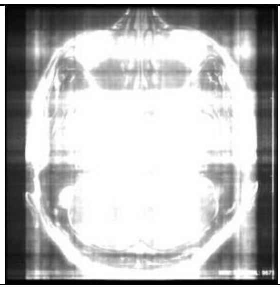
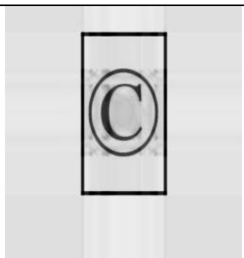
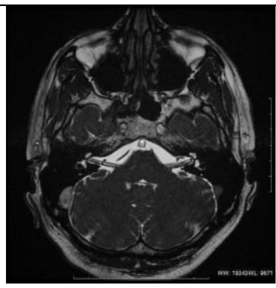
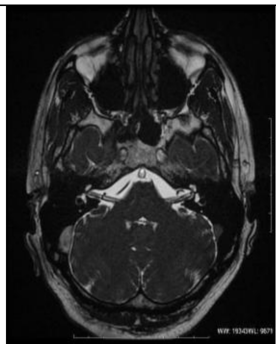
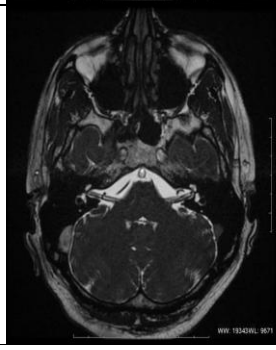
Index	Watermarked	Ext. Watermark
LL		
LH		
HL		
HH		

Table. IV.b: Comparison of different Sub-Image performances in SWT without Attacks

The PSNR and CC values of the given scheme are compared with method [22] in Table V .The comparison of schemes is performed using a = 1, 5 and 9 without any attacks. The suggested method provides better imperceptibility compared to existing scheme.

Sl No	Scaling Factor	Reference	PSNR
1	1	Assini[22]	47.75
		Proposed Method	51.35
2	5	Assini[22]	42
		Proposed Method	43.11
3	9	Assini[22]	40
		Proposed Method	41

Table V. Comparing proposed method with Assini[22]

Further the test is done by considering Lena image of 512X512 (Courtesy SIPI database) as a cover image as shown in Table VI. The work is extended to test the performance with Siddhartha method as in Table VII .for CT image as a cover with the scaling factor of 0.01 to 0.2

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Table VI. Comparing proposed method with Zear[24]

Scaling Factor	Zear[24]		Proposed	
	PSNR	CC	PSNR	CC
0.01	43.88	0.9344	47.54	0.9693
0.02	41.22	0.9764	47.4958	0.9758
0.05	36.53	0.9846	46.9131	0.9806
0.08	33.59	0.9861	45.2956	0.9820
0.1	32.09	0.9852	43.9653	0.9824
0.12	30.85	0.9853	42.8296	0.9828
0.15	29.33	0.9849	41.0479	0.9831
0.2	27.29	0.9851	38.9144	0.9833

Table VII. Comparing proposed method with Siddharth [24].

Scaling Factor	Cover image	Siddharth [25]		Proposed	
		PSNR	CC	PSNR	CC
0.1	Lena	19.4948	0.9990	43.9653	0.9824
	Brain MRI	18.5950	0.9985	47.7215	0.9985

V. CONCLUSION

The paper is implemented with the combination of Stationary Wavelet Transform and Singular Value Decomposition at HH sub-band. The algorithm is applied to Medical Images where Peak Signal to Noise Ratio (PSNR) and Correlation Coefficient (CC) values are calculated before and after applying attacks. The Experiment is conducted for 100 Medical Images as shown in the bar graph for different scaling factors 1, 5 and 9.The correlation coefficient values indicate the input watermark is exactly correlated with extracted watermark as we increase the scaling factor. Therefore the proposed method is robust and has the capability against different attacks which causes the information loss. Further this technique can be used for embedding color watermark images.

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