International Journal of Engineering Research and Technology. ISSN 0974-3154 Volume 10, Number 1 (2017)

A Comparative study of Digital Watermarking algorithms DWT, SVD & DWT-SVD in Medical Field

Jaee P. Gaikwad
PG Student, Department of Electronics Engineering,
D.Y.Patil College of Engg. & Technology,Kasaba Bawada Kolhapur,
Maharashtra, India.

Dr.Mrs.K.V.Kulhalli
Vice Principal and HOD, Department of Information & Technology,
D.Y.Patil College of Engg. & Technology,Kasaba Bawada Kolhapur,
Maharashtra, India.

Prof. S.R.Khot
Associate Professor, Department of Electronics Engineering,
D.Y.Patil College of Engg. & Technology,Kasaba Bawada Kolhapur,
Maharashtra, India.

Abstract
Information and Communication Technologies (ICT) are being adopted widely to improve citizen's health care. Health information systems (HIS) of different hospitals exchange electronic medical records including digital medical images of patients. Medical images and accompanying reports have special requirement of protecting the privacy of the patient by not revealing personal particulars especially when they are transmitted over networks. To increase the security of medical images and preserve patients' privacy, digital watermarking has been proposed. The aim of digital watermarking is to hide some secret information or logo into the multimedia content for protecting the content from unauthorized access or illegal use. Digital image watermarking is a promising domain for various applications, for example, ownership identification, copy protection, authentication, broadcast monitoring, tamper detection & recovery etc. In this paper we are going to compare three different techniques used in digital watermarking. They are DWT,SVD & hybrid DWT-SVD[2].

To evaluate their performance, these schemes are exposed to different geometric and non-geometric attacks. The comparison is made in terms of their performance to sustain to attack. To check effectiveness of these techniques for imperceptibility and robustness, PSNR and NCC parameters are used. The quality of the imperceptibility of the system is calculated by the Peak Signal to Noise Ratio of the watermarked image with original image. The similarity between inserted and extracted watermark is estimated by Normalized Correlation Coefficient.

Keywords: Medical Image watermarking, Discrete Wavelet Transform,Singular Value Decomposition,Peak Signal to NoiseRatio,Normalized(PSNR),Correlation Coefficient(NCC)

Introduction
Exchange of medical images between hospitals has become a natural practice of modern times. The medical images are exchanged for a variety of reasons like teleconferences among clinicians, to discuss diagnostic and therapeutic measures and so on. This exchange of medical images inflicts three restraints for the medical images: (1)only authorized persons have right to use the information,(2) the information has not been changed by unauthorized users and (3) there should be evidence that the information belongs to the correct patient []. On the other hand transmission of medical image and patient data separately through commercial networks like internet results in excessive cost and transmission time. Watermarking is one of the techniques used to address the above two issues[3].

According to the domain in which the watermark is inserted, these techniques are classified into two categories, *i.e.*, spatial domain and transform domain methods. The spatial domain methods modify the digital data (pixels) directly to hide the watermark bits and possess the advantage of low computational complexity. On the other hand, the transform (frequency) domain methods do not alter the pixel values directly but rather modify the transform coefficients to hide the watermark bits such as Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD)[2].

The rest of the paper is organized as follows. Section II provides brief details about the DWT, SVD and DWT-SVD based watermarking algorithms. Experimental study and results are given in Section III. Section IV gives the conclusion & future work.

Methodology

Discrete Wavelet Transform (DWT): This is a frequency domain technique in which firstly cover image is transformed into frequency domain and then its frequency coefficients are modified in accordance with the transformed coefficients of the watermark and watermarked image is obtained which is very much robust. In single level decomposition, DWT decomposes image hierarchically, providing both spatial and frequency description of the image. It decompose an image in basically three spatial directions *i.e.,* horizontal, vertical and diagonal in result separating the image into four different components namely LL, LH, HL and HH. Here first letter refers to applying either low pass frequency operation or high pass frequency operations to the rows and the second letter refers to the filter applied to the columns of the cover image. LL level is the lowest resolution level which consists of the approximation part of the cover image. Rest three levels *i.e.,* LH, HL, HH give the detailed information of the cover image.

DWT Embedding Algorithm: The embedding algorithm for DWT based watermarking is shown in Figure 1. The algorithm works as follows:
Step 1: The original N*N RGB image is transformed into sub-bands using single level 2-D DWT.
Step 2: The watermark of size M*M RGB image is transformed into sub-bands using single level 2-D DWT.
Step 3: The resultant watermark is then embedded into the lower frequency sub-band of original image using the scale factor (α) *i.e.* $WI=O+\alpha W$
Step 4: Finally, inverse 2-D DWT is performed to produce the watermarked image[4].

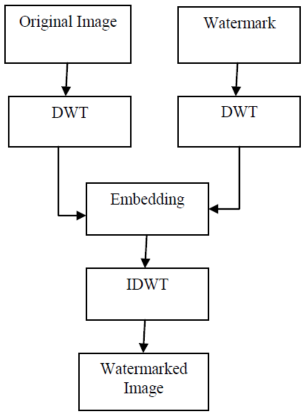


Fig 1: DWT based Embedding

DWT Extraction Algorithm: The extraction algorithm for DWT based watermarking is shown in Figure 2. The algorithm works as follows:
Step 1: The original N*N RGB image is transformed into sub-bands using single level 2-D DWT.
Step 2: The watermark of size M*M RGB image is transformed into sub-bands using single level 2-D DWT.
Step 3: The watermarked image (output of embedding) is transformed into sub-bands using the single level 2-D DWT.
Step 4: Then the extraction is applied to the decomposed watermarked image using the same value of scale factor (α) *i.e.* $EWI=(WM - O)/\alpha$
Step 5: Finally, inverse 2-D DWT is performed to get the extracted watermark image.

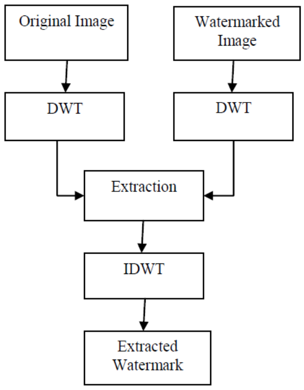


Fig 2: DWT based Extraction

Singular Value Decomposition (SVD): Singular Value Decomposition is a linear algebra transform which is used for factorization of a real or complex matrix with numerous applications in various fields of image processing. As a digital image can be represented in a matrix form with its entries giving the intensity value of each pixel in the image, SVD of an image M with dimensions m x m is given by : $M=USV^T$
Where, U and V are orthogonal matrices and S known as singular matrix is a diagonal matrix carrying non-negative singular values of matrix M. The columns of U and V are called left and right singular vectors of M, respectively. They basically specify the geometry details of the original image. Left singular matrix *i.e.,* U represents the horizontal details and right singular matrix *i.e.,* V represents the vertical details of the original image. The diagonal values of matrix S are arranged in decreasing order which signifies that the importance of the entries is decreasing from first singular value to the last one. This feature is employed in SVD based compression techniques[1].
There are two main properties of SVD to employ in digital watermarking schemes:
1. Small variations in singular values do not affect the quality of image.
2. Singular values of an image have high stability.

Hybrid DWT-SVD: Hybrid technique is a fusion of two techniques. Here, DWT and SVD are used together to improve the quality of digital watermarking and hence increases the robustness and imperceptibility of an image.

Hybrid DWT-SVD Embedding Algorithm: The embedding algorithm for DWT-SVD based watermarking is shown in Figure 3. The algorithm works as follows:
Step 1: The original N*N RGB image is transformed into sub-bands using single level 2-D DWT.
Step 2: SVD is performed on LL sub-band (on RGB components) of decomposed RGB original image *i.e.,* $S=USV^T$
Step 3: The watermark of size M*M RGB image is transformed into sub-bands using single level 2-D DWT.
Step 4: SVD is performed on LL sub-band (on RGB components) of decomposed RGB watermark image *i.e.,* $SW=U_wS_wV_w^T$

International Journal of Engineering Research and Technology. ISSN 0974-3154 Volume 10, Number 1 (2017)

Step 5: After performing SVD on both original and watermark images, the resultant watermark image is then embedded with the original image using the scale factor (α) *i.e.*, $SWI = S + \alpha (SW)$
Step 6: Inverse SVD is performed on embedded image.
Step 7: Finally, inverse 2-D DWT is performed to produce the watermarked image.

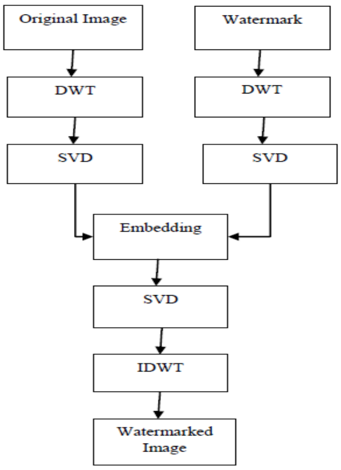


Fig 3: DWT-SVD based Embedding

Hybrid DWT-SVD Watermark Extraction Algorithm: The extraction algorithm for DWT-SVD based watermarking is shown in Figure 4. The algorithm works as follows:
Step 1: The original N*N RGB image is transformed into sub-bands using single level 2-D DWT.
Step 2: SVD is performed on LL sub-band (on RGB components) of decomposed RGB original image *i.e.*, $S = USV^T$
Step 3: The watermark of size M*M RGB image is transformed into sub-bands using single level 2-D DWT.
Step 4: SVD is performed on LL sub-band (on RGB components) of decomposed RGB watermark image *i.e.*, $SW = U_w S_w V_w^T$
Step 5: The watermarked image (output of embedding) is transformed into sub-bands using the single level 2-D DWT.
Step 6: SVD is performed on LL sub-band (on RGB components) of decomposed RGB watermarked image *i.e.*, $SWI = U_w S_w V_w^T$
Step 7: Then the extraction is applied to the resultant SVD image using the same value of scale factor (α) *i.e.*, $EWI = (SWI - S) / \alpha$
Step 8: Inverse SVD is applied on resultant image after extraction.
Step 9: Finally, inverse 2-D DWT is performed to get the extracted watermark image.

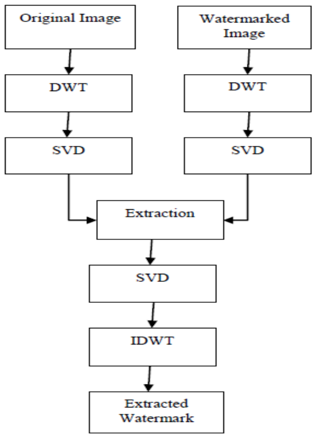


Fig 4: DWT-SVD based Extraction

Experimental Results

For experimental study, we have used ultrasonic medical images as host image in which watermark is embedded. ROI(Region of Interest) & EPR(Electronic Patient Record) are concatenated & used as watermark.

Sample 1	Sample 2	Sample 3	Sample 4
			

Fig 5: Sample Medical Images used as Host Image

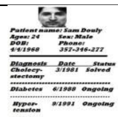
Watermark 1	Watermark 2
	

Fig 6: Watermark Images

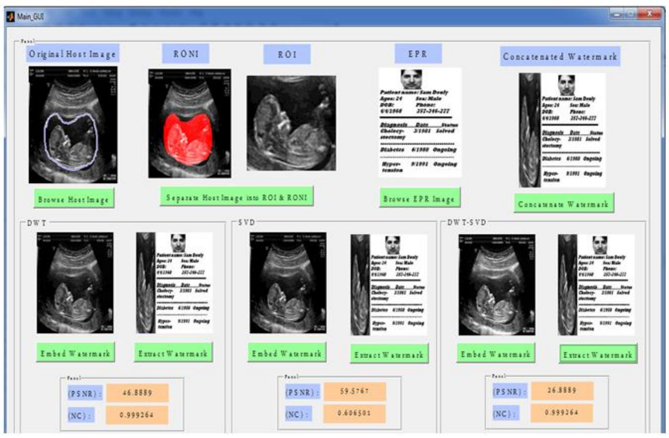


Fig 7:GUI for Embedding & Extraction of watermark

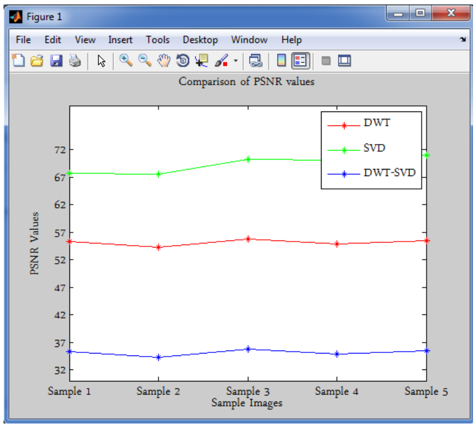


Fig 8:Graph of sample Images against PSNR values

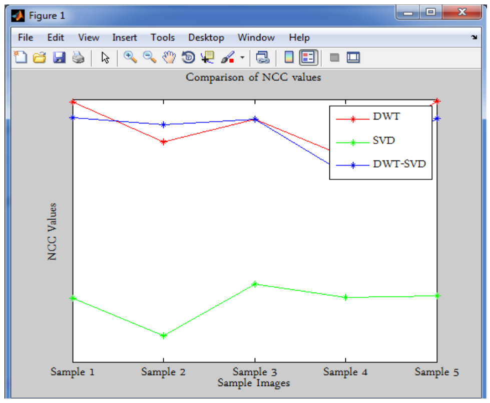


Fig 9:Graph of sample Images against NCC values

Table 1: Comparison of PSNR & NCC values

Medical Images (Host Image)	Concatenated Watermark 					
	DWT		SVD		DWT-SVD	
	PSNR	NCC	PSNR	NCC	PSNR	NCC
Sample 1	55.29	0.990	67.710	0.8864	35.294	0.9901
Sample 2	54.21	0.985	67.492	0.8650	34.214	0.9859
Sample 3	55.7	0.988	70.190	0.8945	35.7	0.9889
Sample 4	54.91	0.957	70.114	0.8871	34.910	0.9576
Sample 5	55.40	0.989	70.921	0.8878	35.408	0.9894

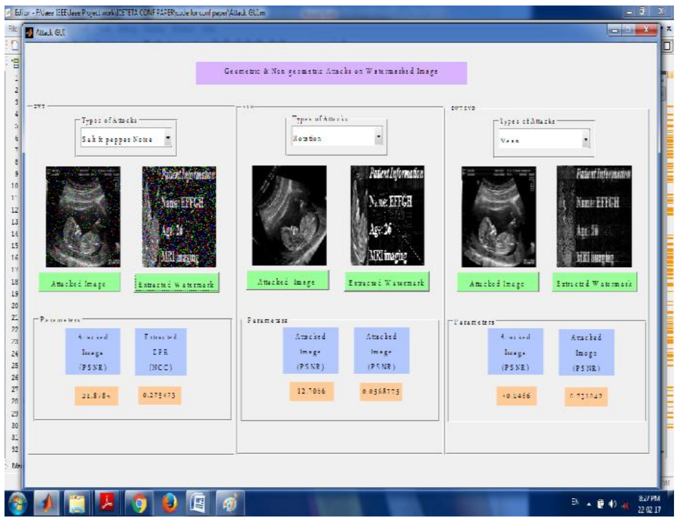


Fig 10: GUI for applying attacks on watermarked image & extracted watermark from attacked watermarked image

International Journal of Engineering Research and Technology. ISSN 0974-3154 Volume 10, Number 1 (2017)
© International Research Publication House http://www.irphouse.com

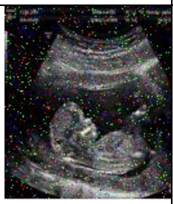
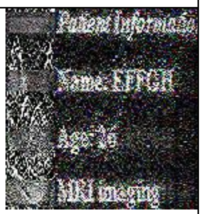
Type of Attack	**DWT**	**SVD**	**DWT-SVD**
Mean Attacked Image			
Extracted watermark			
Salt & Pepper Attacked Image			
Extracted watermark			
Rotation Attacked Image			
Extracted watermark			
Blurring Attacked Image			
Extracted watermark			

Fig 11: Comparison by various attacks

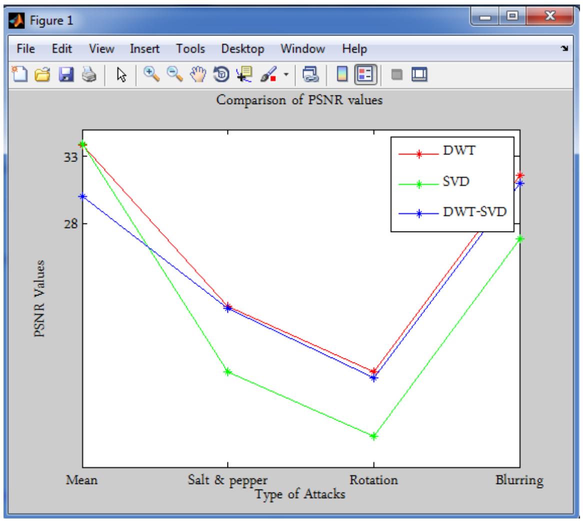


Fig 12:Graph of Type of attacks against PSNR values

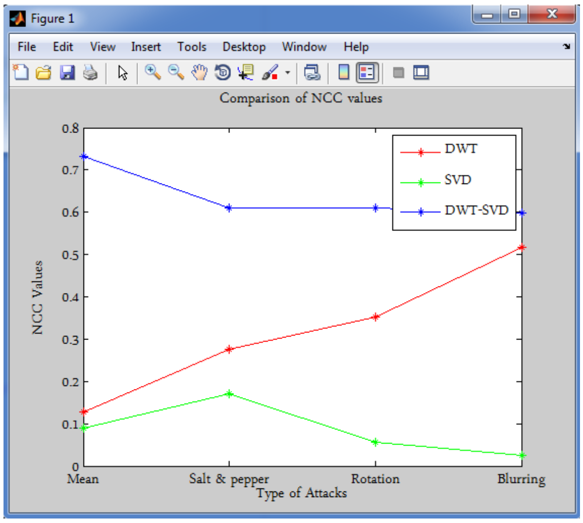


Fig 13:Graph of Type of attacks against NCC values

Type of Attack	DWT		SVD		DWT-SVD	
	PSNR	NCC	PSNR	NCC	PSNR	NCC
Mean	33.860	0.1284	33.953	0.0895	30.046	0.7310
Salt & pepper	21.885	0.2758	17.044	0.1702	21.751	0.6095
Rotation	17.079	0.3519	12.306	0.0568	16.587	0.6097
Blurring	31.621	0.5181	26.871	0.0245	30.990	0.5971

Table 2:Comparison of PSNR & NCC values against various attacks

In the evaluation of the performance of the watermarking schemes, we calculate the peak signal to noise ratio (PSNR) between the original and watermarked images and .normalized correlation coefficient between the original and extracted watermark.Results are also compared by applying various attacks on watermarked images.

Conclusion and Future Work

Medical images may carry sensitive information and additional security measures are required to preserve the privacy of patients. Invisible watermarking has emerged as an effective technique to achieve this goal. In this paper, we have implemented and studied three different and popular watermarking algorithms viz. DWT, SVD and DWT-SVD based watermarking algorithms.We have embedded two different watermarks to test the capacity of the algorithms. We have assessed the quality of the watermarked images using PSNR and NCC. From objective analysis, we found that watermarking has not resulted in any loss of medical information and also, watermarked images are similar to the original images. Further, we conducted different attacks to check the robustness of the watermarking algorithms.

In future work, instead of embedding watermark directly, sparse coding will be applied on concatenated watermark image.Using sparse code,size of watermark is reduced hence only small bits of information is embedded.so quality of watermarked image & extracted watermark will be enhanced.Also if watermarked image undergo various attacks & get tampered then image will be recovered without loss of any information.

References

[1]Afaf Tareef, Ahmad Al-Ani,Hung Nguyen, Yuk Ying Chung,“A Novel Tamper Detection-Recovery and Watermarking System for Medical Image Authentication and EPR Hiding”, IEEE 2014.

[2]Sachin Mehta, RajarathnamNallusamy, Ranjeet Vinayak Marawar, Balakrishnan Prabhakar “A study of DWT and SVD basedWatermarking Algorithms for Patient Privacy in Medical Images”, IEEE International Conference on Healthcare Informatics, 2013.

[3]R. Eswaraiah, E. Sreenivasa Reddy, “ A Fragile ROI-Based Medical Image Watermarking Technique with Tamper Detectionband Recovery” 2014 Fourth International Conference on Communication Systems and Network Technologies

[4]Nidhi Bisla, Prachi Chaudhary,“Comparative Study of DWT and DWT-SVD Image Watermarking Techniques” ijarcsse**,** Volume 3, Issue 6, June 2013

[5]Abhilasha Singh, Malay Kishore Dutta,“ A Blind & Fragile Watermarking Scheme for Tamper Detection of Medical Images Preserving ROI”, 2014 International Conference on Medical Imaging, m-Health and Emerging Communication Systems (MedCom),2014.

[6]Hui Liang Khor ,Siau-ChuinLiew and JasniMohd. Zain, “A Review of Reversible Medical Image Watermarking Scheme with Tamper Localization and Recovery Capability”, IEEE 2014 International Conference on Computer, Communication, and Control Technology (I4CT 2014), September 2 -4, 2014 - Langkawi, Kedah, Malaysia.

[7]Malay Kishore Dutta, Anushikha Singh &M.Parthasarathi, Carlos M. Travieso, “Imperceptible Digital Watermarking in Medical Retinal Images for Tele-Medicine Applications”,2014.

[8]Yatindrapathak,Satishdehariya, “A More Secure transmission of medical images by Two Label DWT and SVD based watermarking technique”IEEE International Conference on Advances in Engineering & Technology Research (ICAETR - 2014), August 01-02, 2014, Dr. Virendra Swarup Group of Institutions, Unnao, India.

[9] Praveen Kumar E, Remya Elizabeth Philip, Sunil Kumar P, Sumithra M G, “DWT-SVD based reversible watermarking algorithm for embedding the secret data in medical images”, 4th ICCCNT 2013 July 4-6, 2013, Tiruchengode, India.