IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 17, Issue 1, Ser. I (Jen. – Feb. 2022), PP 41-45
www.iosrjournals.org

DWT-DCT-SVD Based Biomedical Image Watermarking

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Abstract: *Nowadays, Electronic Patient Records (EPRs) are being used by the hospitals for telemedicine purpose. This record contains information like detail of patient, diagnosis record, information of hospital along with the medical image such as Magnetic Resonance Imaging (MRI), Computed Tomography (CT) etc. In modern global data transmission, there is a compelling need to secure data information from numerous types of unlawful copying and alteration, when transporting such information. Image watermarking, which involves the use of powerful digital picture processing procedures to watermark copyright and verify information inside the image content, is becoming increasingly popular as a remedy to theft and tampering. In the watermarking of any picture, any data securely gets incorporated within picture and may be retrieved by de-watermarking using certain processes to verify validity of user or the information. We used watermarking strategy of fusing DWT-DCT-SVD for grey biomedical picture such that it produces sturdy technique that can withstand different images strikes in this paper. Our approach was also compared to two distinct watermarking techniques: DCT-SVD and DWT-DCT.*

Key words: *Digital Watermarking, DCT, DWT, SVD, Fusion watermarking.*

Date of Submission: 23-01-2022 Date of Acceptance: 06-02-2022

I. Introduction

Grade of a watermarking approach is determined through four aspects: resilience, perceived visibility, throughput, and blind watermarking [1]. As per treatment domain of host picture, picture watermarking methodology is divided in two groups. The first is to change the brightness or luminosity intensity level in the spatial domain [2], as well as the second one is changing the picture coefficients in the frequency domain [3][4]. Singular Value Decomposition (SVD) is currently being utilized in copyright purposes [5][6]. Because frequency domain approaches are resistant to different sorts of strikes like as JPEG compression, media cropping, rotational at a certain angle or mirroring, noise, blur, etc, they are widely employed. The Singular Value Decomposition based watermarking method is likewise particularly resistant to these strikes. Discrete Wavelet Transform has good multi-resolution attribute as well as spatial localization; it is very much same as the human visual system theoretical model. Watermarking methods using DCT or Singular value decomposition give compression. By blending these approaches, further potential refinements in single type of DWT or DCT or SVD based watermarking methodology might be achieved. The idea behind combining these approaches is that the cumulative one might lower the shortcomings occurring in individual approach, hence providing useful technique.

II. Digital Watermarking Based On DWT-DCT-SVD

Discrete Wavelet Transform:

It is a multi-resolution time-frequency analytical technique that may express partial time and frequency domain properties. The main idea is to fragment the picture into sub pictures with different space and frequency, and then process the coefficient. DWT could be implemented as multistage transformation. At level 1 in the DWT domain, an image is split into four sub bands designated LL, LH, HL, and HH, where LH, HL, and HH represent the finest scale wavelet coefficients and LL represents the coarse-level coefficients

Singular Value Decomposition:

SVD of matrix is a linear algebra method that was initially presented by Beltrami and Jordan in the 1870s and has since become widely employed in picture compression and signal processing. The main concept behind SVD based watermarking is locating SVD for cover picture or every block of cover picture, after that for inserting watermark, adjust single value. A picture is viewed being matrix having non-negative scalar listing in SVD transformation. The SVD corresponding to a picture A of dimension m×n gets calculated as follows:

$$I = USV^T$$

Here, V and U denote orthogonal matrices of dimensions m x m and n x n respectively.
S = diagonal (αi), which is singular values' diagonal matrix of dimension m x n.
Right singular vectors for image I are represented by columns of V, also left singular vectors of image I are represented by columns of U.
It's worth noting that the SVD transform's distinctive attribute is that the original image's possible N2 degrees of freedom or samples are now mapped into

S ---N Degrees of freedom
U ---N (N -1) / 2 Degrees of freedom
V---N (N -1) / 2 Degrees of freedom.

DCT transformation:

In many digital signal processing applications, the DCT transforms are widely employed. The DCT transforms are briefly discussed in this section, as well as their importance in the implementation of digital watermarking. Discrete cosine transformations are a method for breaking down a signal into its basic frequency components [23]. It shows a picture as a collection of sinusoids with different magnitudes and frequencies. The DCT coefficients for the transformed output picture, y, are determined using an input image, x, as stated in Eq. 1. In the equation, x represents the input picture, which has N x M pixels, x(m,n) represents the pixel intensity in row m and column n of the image, and y(u,v) represents the DCT coefficient in row u and column v of the DCT matrix.

III. Adopted Methodology

The integrated or fusion technique of picture watermarking utilized in this study meets two goals, namely imperceptibility and resilience. To meet the aforesaid conditions, we employed a mix of discrete wavelet transform (DWT), discrete cosine transform (DCT), and singular value decomposition (SVD). In addition, the watermark picture is directly implanted on the elements of singular values in the DWT sub bands of the original image. The suggested system is made up of our various modules, which are as follows:

1. Watermarking the picture with DCT-SVD/ DWT-DCT/ DWT-DCT-SVD.
2. Application of attacks on watermarked image.
3. Retrieval of watermark picture from the initial picture.
4. Measurement of PSNR and normalization coefficient.

In the proposed model of medical image watermarking, first step is the discrete wavelet transform of the given image, then high frequency coefficients are discrete cosine transformed. The DC vales of DCT blocks are decomposed in matrix form using singular value decomposition. The watermark image is then embedded and inverse DCT and inverse DWT transforms are applied to revert back to the spatial domain. After image strikes are done over this watermarked image, the watermark extraction process is performed and then the performance parameters are measured to check the imperceptibility and robustness with the measurement of PSNR and NC.

IV. Results and Discussion

We have analyzed results of our three different watermarking algorithms in absence and presence of image attacks. We have taken two images named as host1.jpg and host2.jpg as a host image under which we have to hide our watermark images wm1.png and wm2.png. The host1 image is shown in fig 1.1(a) It is MRI of a human brain and the information related to this image are generated as wm1 image shown in fig 1.1(b). Similarly, host2 image is the sonogram of a human foetal operand by ultrasound scan and its respective watermark image is wm2 both images are shown in fig 1.2 (a) and 1.2 (b).

Host Image

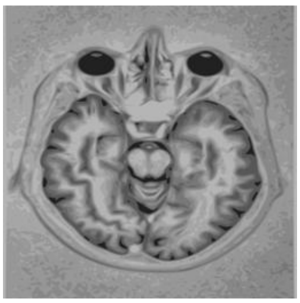


Fig. 1.1 (a)

Watermark Image

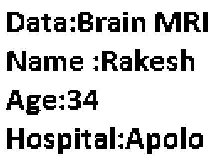


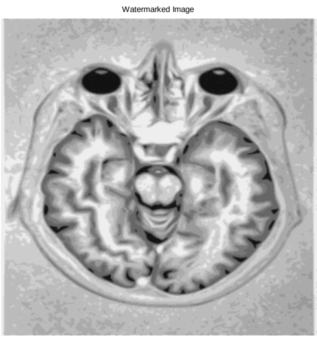
Fig. 1.1 (b)

Both the host images are RGB format and they are converted to the gray scale while the watermark images are consisted of text information and they are taken as black and white images.

Fig. 1.2 (a) **Fig. 1.2 (b)**

Watermarking and De-watermarking of picture using DCT-DWT-SVD:

DCT-DWT-SVD technique has been used to watermark the picture wm1 (fig 1.1 (b)) on host1 image ((fig 1.1 (a)). Figure 1.1(c) shows the picture acquired after watermarking, which is a watermarked image. Then, on the watermark image, no picture strike is applied, and it is de-water marked, with the retrieval of watermarked picture displayed in fig 1.1(d). Fig 1.1(e) is displayed here after applying Gaussian noise on watermarked image fig 1.1 (c), and then the extracted watermark image is shown in fig 1.1 (f).



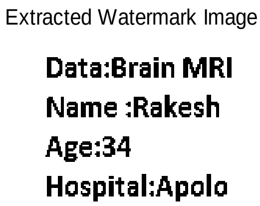


Fig. 1.1 (c) **Fig. 1.1(d)**

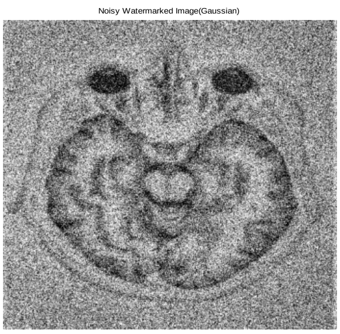


Fig. 1.1 (e) **Fig. 1.1 (f)**

DCT-DWT-SVD technique has been used to watermark the picture wm2 (fig 1.2 (b)) on host2 image ((fig 1.2 (a)). Figure 1.2(c) shows the picture acquired after watermarking, which is a watermarked image. Then, on the watermark image, no picture strike is applied, and it is de-water marked, with the retrieval of watermarked picture displayed in fig 1.2(d). Fig 1.2(e) is displayed here after applying Gaussian noise on watermarked image fig. 1.2 (c), and then the extracted watermark image is shown in fig 1.2 (f).

Fig. 1.2 (c)

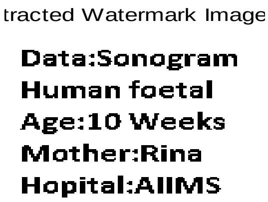


Fig. 1.2 (d)

Fig. 1.2 (e)

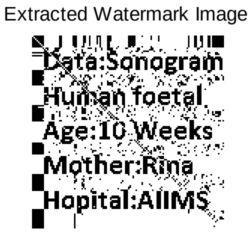


Fig. 1.2 (f)

V. Performance Analysis

The following table gives a comparison of PSNR and NC of the three techniques obtained for watermarking.

Image	Parameters	Methodology	Without Noise	With Gaussian Noise	With salt and pepper noise
Host Image1	PSNR1	DCT SVD	30.498	5.0148	5.0186
		DWT DCT	40.8231	5.0126	5.0163
		DWT DCT SVD	41.2010	8.6614	5.0163
	PSNR2	DCT SVD	Inf	54.0363	54.2718
		DWT DCT	58.8542	50.9982	50.8056
		DWT DCT SVD	Inf	56.6976	53.4935
	NC1	DCT SVD	0.9986	0.9154	0.9032
		DWT DCT	0.9999	0.9152	0.9021
		DWT DCT SVD	0.9999	0.8252	0.9017
	NC2	DCT SVD	1	0.8377	0.8471
		DWT DCT	0.9542	0.6401	0.6176
		DWT DCT SVD	1.0000	0.9157	0.8137
Host Image2	PSNR1	DCT SVD	28.5995	10.9134	10.9176
		DWT DCT	41.0669	10.9221	10.9267
		DWT DCT SVD	41.5630	8.7828	10.9269
	PSNR2	DCT SVD	Inf	54.9820	55.3168
		DWT DCT	56.8449	51.5494	51.3753
		DWT DCT SVD	Inf	57.9248	60.7133
	NC1	DCT SVD	0.9916	0.6143	0.6022
		DWT DCT	0.6022	0.9995	0.6099
		DWT DCT SVD	0.9996	0.6359	0.5965
	NC2	DCT SVD	1	0.8719	0.8821
		DWT DCT	0.9264	0.6773	0.6592
		DWT DCT SVD	1	0.9334	0.9655

VI. Conclusion

Discrete Cosine Transform is used in former, whereas Discrete Wavelet Transform is used in the latter. Various watermarking methods use such common transformations. There is a contradiction between resilience and clarity in such frequency domain approaches. The watermark has been found to be incorporated in the qualitatively most important sections; the system would be resistant to assaults, but the watermark might not be totally hidden. It is easy in concealing watermark if watermarked picture is implanted in less important sections, but the approach might be less resistant to assaults. The use of Singular Value Decomposition (SVD) in picture watermarking is shown. The SVD may be used to see if a genuine bilinear form picture could be supposed to be equal to another. As a superior strategy for watermarking, a unique method for watermarking with fusion of DWT - DCT - SVD has been used here. It has also been reported that the DCT - SVD based approach is quite time intensive, despite the fact that it has a greater capacity and interpretability. DWT - DCT approach is observed to being comparable to the DCT - SVD scheme, with the exception that it is faster. This fusion method can thus meet all of the requirements of an optimal watermarking strategy in terms of concealment, resilience, and quickness. This approach may be used to authenticate photos in order to hide data. Future study will involve the use of this approach to biological photos of various other formats, in particular.

The findings reveal that in the context of watermark image retrieval, which is utilized to signal data based on text in biomedical pictures, the DWT-DCT-SVD based watermarking technique performs well. The findings of the innovative DWT-DCT-SVD watermarking system are analytically confirmed on the measure of PSNR & NC, which are determined to be large.

The study can be expanded in the future to address the effects of other picture strikes as well as code parameter optimization as new picture strikes. The robustness of discussed method with Gaussian noise, salt and pepper noise has also been considered. Compressing, transforming, and cropping effects may be investigated in the future for showing capability of discussed watermark method.

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