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DWT & SVD Based Watermarking Scheme for Copyright Protection In Medical Images

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***Abstract*— Watermarking is a popular method for copyright protection. This technique seems to be very popular and helpful for protecting the privacy of patients by doing watermarking procedure on medical images. In this watermarking scheme a text image is created which may vary from patient to patient and is embedded on the MRI images to generate a secure image which contain hidden patient data (not visible to naked eyes). Two methods are implemented for watermarking i.e. Discrete Wavelet Transform and Singular Value Decomposition. The PSNR (between original MRI image and generated secure image) and correlation (between patient text information and extracted watermark image) are calculated to check the robustness and capacity of the scheme.**

***Keywords*— Watermarking, Real MRI Images, DWT (haar), SVD, PSNR, Correlation.**

1. INTRODUCTION

Watermarking (data hiding) [11] is the process of embedding data or a signature into an image, audio or video file. This embedded data can later be extracted from the multimedia for security and copyright purposes. A watermarking scheme consists of the watermark technique which can be in spatial or frequency domain, an embedding algorithm, and an extraction algorithm. In the applications for information hiding which is used to hide proprietary information, embedded watermarks should be invisible, robust, and trustworthy and have a high capacity.

Medical records carry sensitive personal information of the patient and hence additional security measures are necessary to be taken to protect the privacy of the patient. Generally, personal information related to medical records is stored separately either in digital documents (such as text files) or databases. However, the advancement in digital technology has made easy duplication and distribution of digital data leading to copyright Violation, fraud, forgery and counterfeiting. Researchers have proposed various watermarking methods to protect the digital media from malicious users. Most of these methods depend on embedding invisible information inside the digital media. This invisible information is referred as digital watermark and is extracted from suspected digital media files to validate its authenticity which may not be provided by encryption and firewall [3]. This approach simplifies the work flow of health care systems and as a consequence, it decreases data latency, reduces transcriptional errors, and increases patient safety [1] [2]. In general watermarking scheme should satisfy these characteristics- robustness, imperceptibility, capacity, transparency, security, real time processing, and adjustability.

Medical images carry very sensitive and important diagnostic information and if we are adding invisible watermark it should not change the information which may lead to wrong diagnosis. Digital watermarking can be performed in spatial and frequency domain. In which frequency domain watermarking are more robust as compared to Spatial domain watermarking. Among these two domains watermarking in frequency domain is more robust

as compared to spatial domain [2]. Frequency domain methods are based on transforms such as Fourier Transform (FT) or Fast Fourier Transform (FFT) [5], Discrete Cosine Transform (DCT), and Discrete Wavelet Transform (DWT). Among these DWT based methods are more robust [1]. Besides these frequency domain methods, Singular Value Decomposition (SVD) [6][7][8] based watermarking methods have gained importance because of good compression ratio and less storage required [6]. But if combination of any two methods is performed then it gives much better robust result than the individual methods [10].

In this paper, we are going to study robustness imperceptibility, capacity, and transparency of DWT and

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SVD based watermarking algorithms and their fruitfulness in protecting the privacy of patients. Here we are going to calculate the Peak Signal to noise Ratio and Correlation for the developed watermarking algorithms.

II. SCENARIO OF THE PROPOSED WORK

Some of the patient's lives in rural area. For every patient it is not possible to approach for a specialized doctor or any doctor's second opinion. In such cases or the cases kike any physician was not able to detect the problem, and then the physician refers the case of the patient to other physicians with different specialties and consults them to decide the treatment procedure using the objective. In such cases additional security measures are required to preserve the patient's privacy.

III. DESIGN AND IMPLEMENTATION OF WATERMARKING ALGORITHM

Transform domain watermark embedding techniques offers a higher degree of robustness to image processing operations, compared to spatial domain techniques. Wavelet analysis, in particular, has recently gained attention due to its ability to provide both spatial and frequency resolution [5]. This imposes three watermarking characteristics to be fulfilled. There are many techniques which can be used for watermarking technique in frequency domain. In this paper we are going to consider DWT (widely used in image and video compression applications) and Singular Value decomposition method.

A. Discrete Wavelet Transform based Watermarking

In the last few years wavelet transform has been widely Studied in signal & image processing in general and mostly image compression in particular[1][10]. In some applications wavelet based watermarking schemes performs outstanding than the other frequency domain approaches. One such scheme is proposed here. Among the wavelet family there are many options available. But in this paper we are going to only use haar as it gives much better performance than the others [15] while retrieving the original image and also while retrieving the watermark

For the above reason DWT can be definitely used for robust watermarking purpose. In this paper we are going to implement 2- D DWT algorithm. Here are steps for watermarking based on 2D- DWT.

- Embedding of watermark-

1) Select the MRI image which is to be watermarked and create a watermark having information of the patient and doctor.

2) Decompose MRI image into 2 levels and decompose the watermark W into 2 level bands using DWT.

3) Modified sub-band coefficient = DWT Transform of MRI image + α*(DWT Transform of watermark image) (where α represents the watermarking strength.)

4) Take the inverse transform (IDWT) of modified sub-band coefficient to get the secure watermarked image.

5) Calculate the PSNR between the original and watermarked image.

- Extraction of Watermark-

1) Decompose the watermarked image into 2 levels using DWT.

2) Subtract the watermark image from the watermarked image

3) And Divide the above difference of created watermark image and watermarked image by α.

4) Take the inverse DWT transform.. And we get extracted watermark

5) Calculate the Normalized Correlation between the original watermark and reconstructed i.e. extracted watermark.

B. Singular Value Decomposition based Watermarking

SVD is an effective numerical technique used to analyze matrices[10][6][8]. In SVD transformation, a matrix or say image can be decomposed into three matrices that are of the same size as the original matrix or image. Without loss of any data, if A is a square image like of size 256x256, then SVD of A is defined

$A=USVT$

as where U and V are orthogonal matrices, and S is a diagonal matrix, as

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$$S = \begin{bmatrix} s_1 & & \\ & \ddots & \\ & & s_n \end{bmatrix}$$

Here diagonal elements i.e. s's are singular values and satisfy ≥ ≥…. ≥ ≥=……= =0
In SVD transformation singular values of such refactoring allows us to represent the image with a smaller set of values and it packs the maximum signal energy into as few coefficients as possible.
In this paper because of good stability of and maximum energy representation with few coefficients SVD decomposition can be implemented for watermarking purpose. Here are the steps for watermarking based on SVD technique-

- Embedding of watermark -

1) To embed the created watermark W inside the Original MRI image O, we compute the SVD of both W and O as:
W = UwSwVTw
O = UoSoVTo
2) Watermarked image O' is obtained as:
Sw= So + β*Sw
(β is the watermarking strength.)
O'= UoSwVTo
3) Calculate the PSNR between Original MRI image O and watermarked image O'.

- Extraction of Watermark –

1) To extract the watermark W' original image O', we compute the SVD of O' extract the embedded watermark W' as:
O'= UaSaVTa
2) The reconstructed or extracted watermark is W'
S'w = (Sa − So)/β
(β is watermarking strength.)
W'= UwS'wVTw
3) Calculate Correlation between created watermark W and extracted watermark W'.

Here in both the techniques PSNR and Correlation are the performance parameters for evaluation of embedding and watermarking procedure.

IV. PERFORMANCE PARAMETERS

Watermarking introduces minute changes inside the medical MRI images. These changes may degrade the quality of the watermarked image. To measure the quality of the watermarked image, we have computed Peak Signal to Noise Ratio (PSNR) between the original MRI image and the Watermarked image. PSNR measures the error between the original image and the watermarked image. Also, the medical

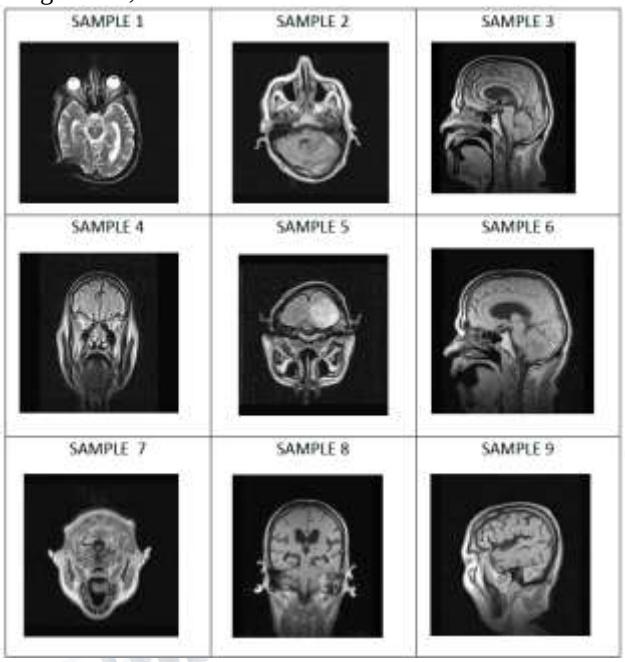

FIG 1. MRI IMAGES (9 SAMPLES ARE TAKEN OF SIZE 256X256)

image may undergo certain attacks such as compression. These attacks may destroy the watermark which is embedded inside the medical image. To measure the robustness of the proposed method, we have computed Normalized Correlation Coefficient (NC) values between the original watermark and the extracted watermark. NC values helps in measuring the similarity between the original watermark and the extracted watermark. Higher NC values indicate that the extracted watermark is more similar to the original watermark and the method is robust and the watermark is successfully extracted.

V. EXPERIMENTAL STUDY AND RESULTS

In this paper MRI image is taken as an Original Image and a text file is generated containing the information of the patient and doctor. Size of Original MRI image is 256x256 and the size patient text is 64x64. Various

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experiments are conducted to develop an efficient medical image watermarking algorithm. But here we are going to perform Discrete Wavelet Transform (Haar) and Singular Value Decomposition. All the techniques discussed in section III are implemented in Matlab.

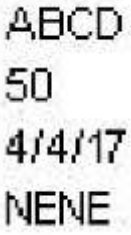

FIG 2. WATERMARK (Having Name of Pateint – ABCD, Age of Patient- 50, Date of Diagnosis- 4/4/17, Name of Doctor- NENE)

Figure 1 are the different types of MRI samples considered of size 256x256. Figure 2 is the watermark created according to the information of patient or doctor. The size of watermark is 64x64. Its size is taken small so that while doing watermarking the data should not destroy the MRI Image.

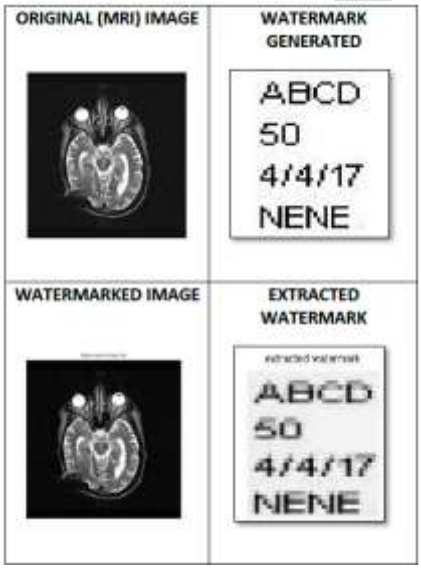

FIG 3- RESULTS DWT BASED WATERMARKING ON MRI IMAGE

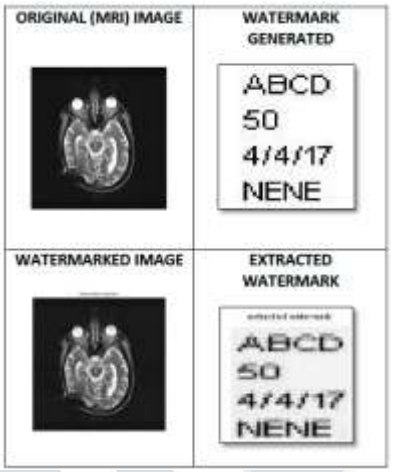

FIG 4- RESULTS SVD BASED WATERMARKING ON MRI IMAGE

Fig 3 and Fig 4 shows the Sample 1 MRI Image, the watermark generated, the watermarked image and the extracted or recovered watermark for DWT and SVD based watermarking technique respectively.

METHOD	DWT		SVD	
	PSNR	*CORREL-ATION*	*PSNR*	*CORREL-ATION*
SAMPLE 1	53.367	0.975	23.056	1.000
SAMPLE 2	54.965	0.964	25.223	1.000
SAMPLE 3	52.632	0.975	24.920	0.999
SAMPLE 4	53.507	0.954	25.349	0.999
SAMPLE 5	53.254	0.975	25.603	0.999
SAMPLE 6	52.256	0.987	25.999	0.999
SAMPLE 7	52.254	0.985	26.073	0.999
SAMPLE 8	51.925	0.964	25.646	0.999
SAMPLE 9	52.254	0.975	25.540	0.999

TABLE 1. VALUE OF PSNR AND CORRELATION FOR WATERMARKING OF PATIENT INFORMATION ON DIFFERENT SAMPLES OF MRI IMAGE

From Table 1 it is observed that value of PSNR for DWT technique is high as compared to SVD technique. And the value of Correlation for SVD is high as compared to DWT method.

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The characteristics to be satisfied by any watermarking technique are watermark must be invisible i.e. imperceptible, robust, and trustworthy and have a high capacity. According to Table 1. DWT method is more imperceptible as compared to SVD. And SVD is more robust because value of correlation is high as then DWT.

VI. CONCLUSION

In this paper we have implemented two methods or watermarking on MRI images for patient privacy or copyright protection in the medical field. PSNR and Correlation are the performance parameter taken for quality analysis.
From the analysis it is observed that both the methods are suitable for watermarking. From the results it is observed that DWT method is more imperceptible as compared to SVD as value of PSNR for DWT>SVD. And SVD is more robust and has more capacity because value of correlation is high as then DWT.

VII. FUTURE WORK

In addition to this we can also compare other digital watermarking technique with the implemented techniques in this paper. We can also apply attacks like Gaussian noise, rotation etc for checking the robustness of the implemented watermarking techniques.

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