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Watermarking based on DWT and SVD Algorithmin Medical Image

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Abstract—Medical images and accompanying reports have requirement of protecting the privacy of patient. The paper deals with the use of watermarking technique to increase the security of medical images and preserve patient's privacy.The operation of embedding and extraction of watermark are done by using different watermarking algorithmsi.e Discrete Wavelet Transform, Singular Value Decomposition. Watermark is a normal image to be generated every time and which is to be embeddedinside medical images. Then the quality ofwatermarked images which is obtained after embedding the watermark is to be accessed by calculating Peak Signal to Noise Ratio (between original and watermarked image) and Normalized Correlation (between the original watermark and extracted watermark).

Keywords- *DWT, SVD, MRI Images, PSNR, Correlation.*

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I. INTRODUCTION

All Safety and quality of patient care are pre-requisite forhealth care organizations. To improve safety and quality of patient care, various organizations are integrating Electronic Health Records (EHR) with their Health Information Systems (HIS). This approach simplifies the work flow of health caresystems and as a consequence, it decreases data latency, reduces transcriptional errors, and increases patient safety [1] [2]. Medical records carry sensitive personal information and hence additional security measures are required 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 enabled easy duplication and distribution of digital data leading to copyright Violation, fraud, forgery and counterfeiting. Researchers have proposed various watermarking methods to protect the digitalmedia 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.

Watermarking will raise the existing security standards and also, it will provide ultimate authenticity whichmay not be provided by other security tools such as encryption and firewall [3]. Medical images may contain very sensitive information about the patient's health condition which is not supposed to be revealed to any user other than those authorized to know as per requirements and standards. While the identifier can be included as a text in the accompanying text file, it can be invisibly embedded in the image providing additional security.The identifier can be Patient ID or any other information linked to the patient.

II. DIGITAL WATERMARKING

Digital Watermarking is a recently emerged research area, which is aimed for copyright protection. The most important use of watermark is identification of origin of data, finding unauthorized person or and then disabling the content.Medical images carry very sensitive information and if we are adding invisible watermark it should not change the information which may lead to wrong diagnosis. For very secure, robust, imperceptible, high capacity, transparent watermarking many types of spatial and digital watermarking are introduced. In which frequency domain watermarking are more robust as compared to Spatial domain watermarking. 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. 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. In this we are going to study the DWT and SVD based algorithm for watermarking the information of the patient on the MRI Images.

Security of medical information, derived from strict ethics and governmental rules, gives rights to the patient and duties to

the health professionals. This imposes three compulsory characteristics: robustness, imperceptibility, capacity.

- Robustness-

Robustness is defined as the ability of watermark to resist against both lawful and illicit attacks. The embedded watermarks should not be removed or eliminated by unauthorized distributors using common processing techniques including; compression filtering, cropping, quantization and others [2].

- Imperceptibility-

One of the stringent requirements of the image watermarking is the imperceptibility. Imperceptibility means that watermark embedded in the image must be invisible to the human eye[2].

- Capacity-

In watermarking of medical images, all the information necessary for physician such as identification of patient, diagnosis report, origin identification (who created the image) are embedded. This information is further increased when the image is sent to other physician for second opinion. Therefore, capacity for embedding the payload must be high [2].

III. DESIGN AND IMPLEMENTATION OF WATERMARKING ALGORITHM

Medical image watermarking requires extreme care when embedding additional data within the medical images because the additional information must not affect the image quality as this may cause a misdiagnosis. This kind of a system requires a high level of security, which can be ensured by using digital watermarking techniques. This imposes three mandatory characteristics: robustness, capacity and imperceptibility. There are different methods that has been using for medical image watermarking. In this project we are going to work on two methods

A. Singular Value Decomposition

B. Discrete Wavelet Transform

A. SVD based Watermarking using MATLAB

SVD is an effective numerical analysis tool used to analyze matrices. In SVD transformation, a matrix can be decomposed into three matrices (U, S, V) which are of same size of the original image. In this this section stepwise algorithm is explained briefly which can be implemented in Matlab.

- **Watermark Embedding** -

  To embed the watermark W inside the Original MRI image O, we compute the SVD of both W and O as:

  $W = UwSwV^{T}w$

  $O = UoSoV^{T}o$

  Watermarked image O' is obtained as:

  $Sw = So + \beta Sw$ (β is the watermark embedding strength.)

  $O' = UoSwV^{T}o$……. Watermarked Image

- **Watermark Extraction** –

  To extract the watermark W' from attacked image O'', we compute the SVD of O'' and then extract the embedded watermark as:

  $O'' = UaSaV^{T}a$

  $S'w=(Sa - So)/\beta$ (β is the watermark embedding strength.)

  $W' = UwS'wV^{T}w$…….Extracted Watermark

B. DWT based Algorithm using MATLAB

Discrete Wavelet transform (DWT) is a mathematical tool for hierarchically decomposing an image. It gained widespread acceptance in signal processing, image compression & watermarking. It decomposes a signal into a set of basis functions, called wavelets. Wavelet transform provides both frequency and spatial description of an image. In this this section stepwise algorithm for DWT based watermarking is explained briefly which can be implemented in Matlab.

- **Watermark Embedding**-
  1. Read the Original Image O.
  2. Read the watermark W.
  3. Decompose O into 2 levels and decompose the watermark W into 2 level bands using DWT
  4. Modified sub-band coefficient = DWT Transform of Original Image + α*(DWT Transform of watermark image)
     (where α represents the watermarking strength.)
  5. Take the inverse transform (IDWT) of modified sub- band coefficient to get the watermarked image.
  6. Calculate the PSNR between the original and watermarked image.

- **Watermark Extraction**-
  1. Read the watermarked image
  2. Decompose the watermarked image into l levels using DWT
  3. Read the watermark image
  4. Subtract the watermark image from the watermarked image
  5. Divide the above difference by α.
  6. Take the inverse DWT transform.
  7. Reconstructed image is obtained
  8. Calculate the Normalized Correlation between the original watermark and retrieved watermark.

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IV. PERFORMANCE EVALUATION PARAMETERS

A. *PSNR (Peak Signal to noise ratio)*

For quantitative measurements, the Original MRI image perceptibility is determined using PSNR values. Two common performance evaluation metrics are combined to form the fitness function, the Peak Signal to Noise Ratio (PSNR) [12]. The Peak Signal to Noise Ratio (PSNR) is utilized to evaluate image quality. PSNR of watermarked image should not go below some level after attack so we can use PSNR for performance evaluation between different outputs we got from diff. algorithms. To check the visual distortions of watermark image we calculate the Peak Signal to Noise Ratio (PSNR). There has been much emphasis on the robustness of watermarks to common signal processing operations such as compression and signal filtering.

For PSNR first calculates the mean-squared error using the following equation

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

The peak signal to noise ratio (PSNR) is calculated by using the formula:-

$$PSNR = 20\log_{10}\left(\frac{255}{\sqrt{MSE}}\right)$$

Where MSE is the root mean square error and 255 is the maximum value of luminance level.

B. *Correlation*

The correlation factor measures the similarity between the original watermark and the watermark extracted from the attacked watermarked image (robustness) [12]. The correlation factor may take values between 0 (random relationship) to 1 (perfect linear relationship).

Formula: $\rho = \frac{X}{(row * column)}$

$$X = \sum_{i=1}^{N} (W_i * B_i)$$

where: - W = watermarked image, B = watermark image

V. RESULT AND COMMENT

A MRI image is taken as an Original Image and a text file is generated containing the information of the patient. Size of Original MRI image is 256x256 and the size patient text is 64x64. Various experiments are conducted to develop an efficient medical image watermarking algorithm. The first experiment is conducted is Singular Value decomposition method.

ORIGINAL (MRI) IMAGE	WATERMARK GENERATED
	
WATERMARKED IMAGE	**EXTRACTED WATERMARK**
	

Table 1. Results SVD based watermarking on MRI image

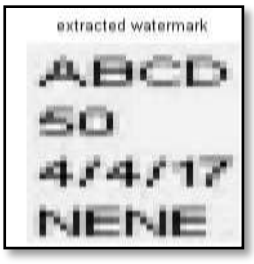
ORIGINAL (MRI) IMAGE	WATERMARK GENERATED
	
WATERMARKED IMAGE	**EXTRACTED WATERMARK**
	

Table 2. Results DWT based watermarking on MRI image

Name of Technique	*PSNR*	*CORRELATION*
SVD	**57.638828dB**	**0.998708dB**
DWT	**41.043870dB**	**0.999942dB**

This techniques can be performed by using more number of samples. For every MRI image the PSNR may vary. From the above table we can say the value of PSNR for SVD based watermarking is more as compared to DWT based method but the correlation of DWT based watermarking is more as compared to SVD based method.

VI. FUTURE WORK

The future work can be are-

1. Combination of DWT and SVD method for watermarking.
2. Apply the different attacks with varying strength for checking the robustness of watermarking algorithm.
3. We can use other wavelet type from wavelet family and compare which wavelet type gives better PSNR and correlation.

VII. CONCLUSION

Watermarking is a popular method for copyright protection and we have implemented an invisible watermarking for the application fulfillment in the Medical field. This type of Invisible watermarking are very helpful inhealthcare industry which demands secure, robust and more information hiding techniques promising strict secured authentication.

From the above two method implemented we can conclude that DWT based algorithm are very useful in application were Imperceptibility is important as correlation is more & SVD is useful in application were Robustness is important. In all Both methods can be used for medical image watermarking for copyright protection.

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