DIGITAL WATERMARKING FOR MEDICAL IMAGES USING DWT AND SVD TECHNIQUE

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Abstract: In the modern world with developing technologies, all the information are collected and stored digitally. In medical field also the diagnostic information are recorded digitally and transmitted. While transferring the information digitally, security and authenticity is the main aspect to be concentrated. Watermarking is the technology which ensures the authenticity and security of the medical images, information about patient and diagnostic details. In this paper, hybrid watermarking technique by the combination of Discrete Wavelet Transform and Singular Value Decomposition is implemented, because of its high security and efficiency as compared with other frequency domain watermarking. The images have been tested against attacks like salt and pepper noise, Gaussian noise, and filtering attack. Efficiency and performance of this hybrid technique are evaluated based on PSNR, SSIM and NC. From the simulation results, PSNR is above 37 dB, which ensures better imperceptibility and shows better robustness with NC values near to 1 against image attacks during transmission.

Keywords: Medical image watermarking, DWT, PSNR, singular value decomposition.

1 Introduction

In the digital era, the rapid development of technology in the modern world has made it easy to transfer images, text, audio and video. While sharing confidential data, security of the information plays a vital role. Security and authenticity are the most important parameters in medical image transfer. Because of the widely used images, it is essential to protect the more confidential information from duplication and access by unauthorized user. [1] Cryptography is the technique used to protect the digital media. After decrypting the content of the media, there won’t be any further protection for the media and hence it may lead to illegal access of the information. To overcome these disadvantages, digital image watermarking is used. Digital watermarking is the technology which is helps to protect data and to authenticate digital images without degrading the visual aspect of original image. Robustness, authenticity, security, imperceptibility, and capacity are the important aspects which determine the efficiency of the digital watermarking techniques. [2] Spatial domain and transform domain techniques are the two major classes of digital watermarking. Watermarking in spatial domain is based on manipulating the pixel values in the images. [3] Though it takes less time and it is less complex, its inadequate robustness for various image attacks make it quite inefficient as compared to watermarking techniques in transform domain. Watermarking in transform domain, the images are represented in terms of frequencies. Transform method is applied to the input image, after that watermark is inserted in the coefficients of transformed image. At last, inverse transform is implemented to obtain watermarked image. Some of the
frequency domain techniques are based on Discrete Cosine Transform (DCT), Discrete Fourier Transform (DFT), and Discrete Wavelet Transform (DWT). DCT is used to modify the low frequency coefficient. DFT is used for signal study, analysis and is strong against geometric image attacks. (cropping, rotation) DWT is used for non-stationary signal processing, used for image decomposition. [4] Singular Value Decomposition (SVD) is used for data manipulation with less loss and data denoising and also provides intrinsic geometry properties of images. In this paper, combination of DWT and SVD was proposed, due to its better efficiency in robustness and imperceptibility.

1.1 Literature Survey

[5] Frank Y Shih and Xin Zhong (2016) proposed scheme for medical image watermarking, in that multiple ROIs are selected and preserved, watermark embedded in regions of non-interest (RONI). To avoid piracy the watermark is embedded in frequency domain.

[6] Poonam and Shaifali (2018) proposed system provides a robust digital watermarking technique which incorporates both DWT transformation and SVD. Robust watermarking exhibit the property of sustainability and application for the copyright authentication. The obtained values of MSE, PSNR and SSIM obtained from DWT-SVD provides good imperceptibility and robustness.

[7] Habib Ayad and Mohammed Khalil (2018) proposed a technique in which SVD and DWT are used to hide a textual data in to original medical images. QAM is used for encoding the textual characters. PSNR, SSIM and CER values shows that this technique provides high robustness and good imperceptibility.

[8] Usha Verma and Neelam Sharma (2019) proposed a work in that, various watermarking techniques based LSB, DCT, SVD, discrete wavelet transform and hybrid techniques are implemented. The performance of each technique is estimated using on the PSNR, SSIM and CRC values. The results show that the hybrid technique provides more security than other techniques.

[9] Mohamed Ali Hajjaji (2019) proposed an efficient and a novel image watermarking system implemented in hardware using Haar Discrete Wavelet Transform and this hardware simulation results shows the efficiency of the implemented architecture based on imperceptibility and robustness against various image attacks.

[10] Mahbuba Begum and Mohammad Shorif Uddin (2020) proposed a Watermarking Technique for digital images. Authors analysed the details of standard watermarking system frameworks. They concluded that DWT based watermarking is a highly efficient method and so the robust and most secure techniques are use in this method.

[11] Abdul Joseph Fofanah (2020) proposed the Discrete Cosine Transform (DCT), Genetic Programming (GP), DWT and Evolutionary algorithms based watermarking for providing dual watermarking protection. Using DCT and DWT we get a watermarked image for both coloured image as well for grey image. In second method we can use GP and either DCT or DWT method.
2 METHODOLOGY

2.1 WATERMARK EMBEDDING

In our proposed work, 1-level DWT is implemented to the input medical image, and then LH sub band coefficients are chosen to embed the watermark. SVD is applied on LH sub band then diagonal matrix is chosen. In watermark image, LH sub band is chosen after the implementation of first level DWT. SVD is applied on LH band then singular diagonal matrix chosen. Then scaling factor (0.1) is multiplied with this diagonal matrix. Add the diagonal matrix that are obtained from original medical image and watermark image. Inverse SVD (ISVD) is applied on the diagonal matrix. Watermarked image is obtained after applying Inverse DWT (IDWT) with the modified sub band.

![Watermark Embedding Process](image)

**Fig. 1.** Watermark Embedding Process

2.2 WATERMARK EXTRACTION

In watermarked image, 1-level of DWT is applied and LH sub band is chosen. SVD is applied on LH sub band and diagonal matrix is chosen. In original medical image, 1-level of DWT is implemented and LH sub band is chosen. SVD is implemented on LH sub band and diagonal matrix is chosen. Subtract the diagonal matrix that are obtained from original image and watermarked image. Divide the matrix by scaling factor (0.1). ISVD is applied on the diagonal matrix. Then IDWT is applied to obtain original watermark.
3 RESULTS

The proposed watermarking technique enhances capability to transfer the data confidentiality and to recover the information without any distortion and it helps to identify the authenticity of the transferred image. [12] Many performance metric were suggested for estimating the efficiency of this watermarking technique. The most widely used criteria for measuring the imperceptibility is Peak Signal to Noise Ratio (PSNR), Structural Similarity Index Measurement (SSIM) and the robustness is Normalized Coefficient (NC).

3.1 Peak Signal to Noise Ratio (PSNR)

Quality of the image measured using PSNR value. The ratio of maximum possible values of a signal to the power of distorting noise is given as PSNR. If x is the cover image and y is the watermarked image, the PSNR is computed as:

$$PSNR = 20 \log_{10} \left( \frac{\max(x(i,j))}{\frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} (x(i,j)-y(i,j))^2} \right) \quad \ldots \ldots \ldots (1)$$

M and N are the length and width of the cover image. If the PSNR value is high [13-14], the watermark is more invisible.
3.2 Structural Similarity Index Measurement (SSIM)

SSIM index is a full reference metric used for measuring similarities of images. It looks on local rather than global image similarity. It can be expressed as:

\[
SSIM = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{\mu_x^2 + \mu_y^2 + \sigma_x^2 + \sigma_y^2 + C_1} \times \frac{2\sigma_{xy} + C_2}{\sigma_x^2 + \sigma_y^2 + C_2}
\]  

(2)

Where \( \mu_x, \mu_y \) represents the mean of the host and the watermarked image, standard deviation of host and watermarked image represented as \( \sigma_x, \sigma_y \), \( C1 \) and \( C2 \) are constants, that dependent on the dynamic range of the value of the pixel.

3.3 Normalized Coefficient (NC)

It is used to quantify the similarity between embedded and extracted watermark.

\[
NC = \frac{\sum_{j=1}^{M} \sum_{i=1}^{N} (x(i,j) - \mu_x)(y(i,j) - \mu_y)}{\sqrt{\sum_{j=1}^{M} \sum_{i=1}^{N} (x(i,j) - \mu_x)^2 (y(i,j) - \mu_y)^2}}
\]  

(3)

Where \( M \) and \( N \) are the length and width of the watermark image, \( x \) and \( y \) are the embedded and the extracted watermark images, \( \mu_x \) and \( \mu_y \) represents the mean of embedded and extracted watermark. If NC value is low, extracted watermark is less distorted and it ensures the high robustness of the watermarking scheme.
Fig. 3. Sample test images (a) Image 1 (b) Image 2 (c) Image 3 (d) watermark

The proposed watermarking technique implemented in test images taken from the standard online medical image database [15] are considered as original cover image and copyright logo as watermark image. Watermarking scheme was implemented using MATLAB 2014 and is implemented on Intel core i3, 3.30 GHz with 4 GB RAM

Table 1. Performance metric values of watermarking scheme for sample test images without attacks

| Without Attack | PSNR (dB) | SSIM | NC |
|----------------|----------|------|----|
| Image 1        | 41.23    | 1    | 1  |
| Image 2        | 40.69    | 0.9998 | 1  |
| Image 3        | 42.11    | 0.999 | 0.998 |

Results shown in Table 1 states that imperceptibility is good for the watermarked image (PSNR values above 40dB and SSIM very close to 1) and better NC values of the watermark after extraction. Robustness of the implemented technique tested against attacks like noise and filtering attack. Results tabulated in Table 2, indicates that the proposed technique has good robustness (NC values near to 1) and imperceptibility of the watermark image also good with above 37 dB

Table 2. Performance metric values of watermarking scheme for sample test images against Salt & Pepper Noise, Gaussian noise and filtering Attack

| Attacks                  | Image samples | PSNR (dB) | SSIM | NC  |
|--------------------------|---------------|-----------|------|-----|
| Salt & Pepper Noise      | Image 1       | 37.19     | 0.984 | 0.993 |
| (density = 10%)          | Image 2       | 37.36     | 0.987 | 0.988 |
|                          | Image 3       | 38.73     | 0.991 | 0.986 |
| Gaussian Noise           | Image 1       | 36.71     | 0.981 | 0.991 |
| (variance = 0.01)        | Image 2       | 37.13     | 0.985 | 0.983 |
|                          | Image 3       | 36.47     | 0.989 | 0.982 |
| Median Filter            | Image 1       | 39.24     | 0.991 | 0.993 |
| (5x5)                    | Image 2       | 38.69     | 0.989 | 0.987 |
|                          | Image 3       | 38.81     | 0.987 | 0.985 |

4 CONCLUSION

An efficient watermarking scheme based on the combination of DWT and SVD was implemented. The efficiency of the watermarking scheme enhanced by the properties of DWT and SVD techniques.
properties helps in preserving the data for watermark extraction and SVD helps to make the watermarking technique higher invisibility. The proposed scheme ensures the protection of copyright and authentication of the transferred diagnostic images for tele-diagnosis by extracting the watermark. After various attacks like Gaussian noise attack, salt and pepper noise attack, and median filtering attack, the watermark is extracted with better the robustness and imperceptibility with the PSNR values above 37d, NC values near to 1 and SSIM values near to 1. The proposed system overcomes the drawbacks in conventional single transform domain watermarking techniques. Future work will focus to develop the watermarking scheme for colour images and watermarking for videos.

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