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ROBUST WATERMARKING PROCESS FOR MEDICAL IMAGES USING DISCRETE WAVELET AND GAUSSIAN NOISE

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Abstract: Image Watermarking has become an important technique nowadays for the copyright protection. In this paper, a new wavelet-based watermarking scheme is proposed. The experimental results show the efficiency of the watermarking scheme, which emphasize a good combination between Gaussian noise and Daubechies wavelet. The PSNR (Peak signal to noise ratio) index is used to perform the evaluation of watermarking between host and watermarked images. For a set of ten sequential images a significant increase in the PSNR value is observed when the images contain a higher gray pixels area.

Keywords: watermarking, Daubechies wavelet, Gaussian noise, peak signal to noise ratio.

INTRODUCTION

For many decades, the functions as sines, cosines, Fourier analysis or wavelets transform have been used to approximate, compress or watermarking of the signals. The watermarking process is a signal embedded into the host digital images in order to be protected. They contain useful information for the owner such as name producer, company logo, signature, and so on.

The watermarked properties must respect two important issues; the first one is that the watermark embedding should not alter the quality of the host image; the second property is robustness of image distortions (Langelaar, *et al.*, 2000).

In this study the 2-D wavelets transform is chosen in the watermarking process because it decomposes images into both spatial and spectral local coefficients (Lewis and Knowles, 1992), and helps us to embed the information inside the images. The most interesting advantage of wavelet transforms is that individual wavelet functions are localized in space. In this paper, I processed brain MRI images where the interpolation of the high-frequency sub-bands obtained by discrete wavelet transform (DWT) was applied.

The proposed watermarking scheme respects the three main steps, embedding, attack and detection. The first step consists of embedding the information in digital image, the second one is the attack, it is performed with white Gaussian noise, and the third one is the detecting of the attacked signal. Usually, in the first stage it is used the wavelets transform (Kumar, *et al.*,2018). My proposal supposes the Daubechies wavelet to do this. The second stage can be replaced with a logo or author signature, but I proposed this type of noise because I want to see how efficient my watermarking scheme is. The last stage involves the PSNR index to evaluate the quality of information hidden in the image (Keyvanpour and Merrikh-Bayat, 2011). The PSNR (dB) computes the peak signal-to-noise ratio between two images. This ratio is used as a quality measurement between the original and the distorted images (Hore and Ziou, 2020).

The outline of this paper is as follows. Section II describes the related work. Section III describes the mathematical approach, in section IV a watermarking scheme is proposed, in section V, I show the experimental results and discussions. The conclusion and the future work are presented in section VI and all the used references are described in section VII.

RELATED WORKS

Bhatnagar and Raman (Bhatnagar and Raman, 2010) presented in their paper "A new robust reference watermarking scheme based on DWT-SVD" a new semi-blind watermarking scheme based on DWT and singular value decomposition SVD for copyright protection and authenticity.

Huang and Shi (Huang and Shi,1998) used a visual masking made of luminance and texture developed in the DCT domain.

Eggers et al. (Eggers et al., 2000) showed a practical scheme in watermarking process that employs a lattice-structured codebook. The performance of the proposed scheme is compared to the theoretical information.

A robust image watermarking technique for copyright protection based on 3-level DWT was implemented by Kashyap and Sinha (Kashyap and Sinha, 2012). In their scheme a multi-bit watermark is embedded into the low frequency sub-band of a host image by using alpha blending technique. They compared the method with the 1-level and 2-level DWT based image watermarking methods by using a statistical parameter such as PSNR.

MATHEMATICAL APPROACHES

3.1 Daubechies wavelets

The Daubechies wavelets DWT which helps to perform increasing the accuracy of watermarking separating of an image into a set of wavelets.

The scaling functions and wavelet functions are defined by the next two equations (1) and (2) respectively.

$$(1)\ \Phi(t)=\sum_{n=0}^{4}h[n]\cdot\Phi(2t-n)$$

$$(2)\ \psi(t)=\sum_{n=0}^{4}g[n]\cdot\Phi(2t-n)$$

where

$$h[0]=\frac{1+\sqrt{3}}{4\sqrt{2}},\ h[1]=\frac{3+\sqrt{3}}{4\sqrt{2}},$$

$$(3)\ h[2]=\frac{3-\sqrt{3}}{4\sqrt{2}},\ h[0]=\frac{1-\sqrt{3}}{4\sqrt{2}},$$

and

$$(4)\ g[0]=h[3],\ g[1]=-h[2],\ g[2]=h[1],$$
$$g[3]=-h[0].$$

This generated coefficients are grouped into four sub-bands Average / Lower Frequency (A/LF), Horizontal / middle frequency (H/MF), Vertical / middle frequency (V/MF) and Diagonal / Higher Frequency (D/HF) as in table 1. So the input image can be decomposed into four multi-resolution sub-bands of data (Kumar, et al., 2018).

Table 1. The sub-bands generated by Daubechies wavelets

A/LF	H/MF
V/MF	D/HF

3.2 Peak signal to noise ratio (PSNR)

The PSNR index is most commonly used to measure the quality of the watermarking process. It is applied between the host and watermarked images.

To compute the PSNR index, firstly it is calculated the mean-squared error (MSE) using the following equation:

$$(5)\ MSE=\frac{\sum_{M,N}\left[I_1(m,n)-I_2(m,n)\right]^2}{M\times N},$$

$$(6)\ PSNR=10\log_{10}^{\left(\frac{R^2}{MSE}\right)}$$

where, M and N are the numbers of rows and columns in the input images. R is the maximum fluctuation in the input image of data type (AL-Nabhani, *et al.,* 2015).

WATERMARKING SCHEME

A new scheme able to solve most of the practical issues of watermarking is designed (see figure 1). The main idea of this kind of digital watermarking schemes is to carry secret copyright information by means of Daubechies wavelets. The proposed algorithm has the advantage of using the Gaussian noise and discrete wavelet transform. In order to evaluate the performance of watermarking scheme the PSNR index was applied.

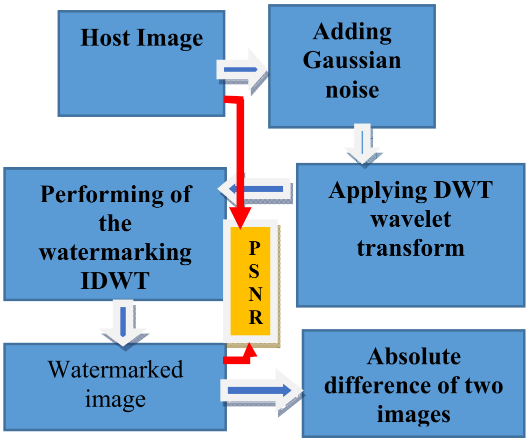
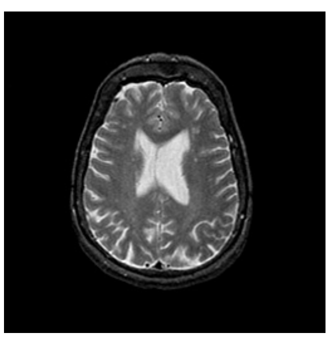


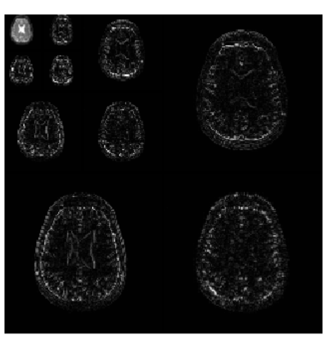
Fig. 1. The pipeline of our watermarking scheme.

EXPERIMENTAL RESULTS AND DISCUSSIONS

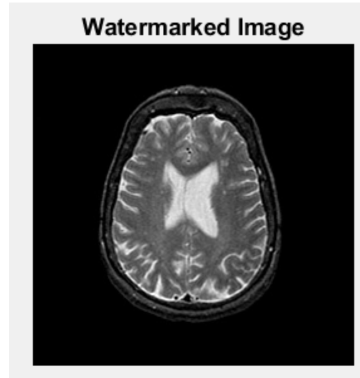
In this section, some experimental results are shown to check the proposed watermarking scheme. In my scheme, a white Gaussian noise is used as the watermarking key applied on 256x256 MRI brain images. The host image is shown in fig. 2(a), fig. 2(b) contains the decomposed image with Daubechies wavelets, this stage is generated by the wavelet coefficients; fig.2(c) watermarked image; the watermarking key belongs to fig. 2(d) and the difference between the host image and watermarked image is shown in fig. 2(e).



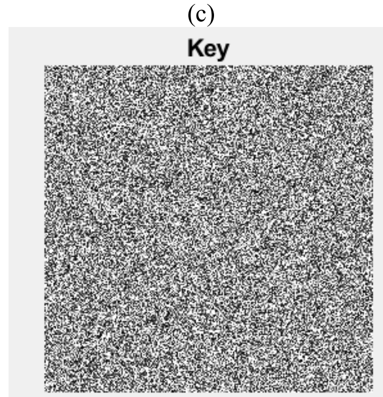
(a)



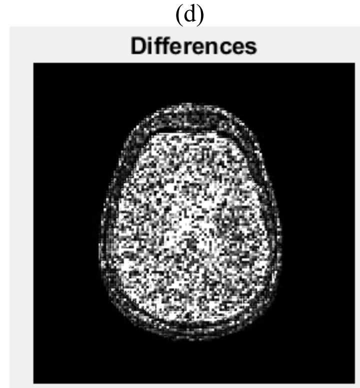
(b)



(c)



(d)



(e)

Fig.2. Processed images with watermarking process

In performing the watermarking stage the weight of watermarking is initialized being considered as a watermarking key.

In the following graph, the calculated values of PSNR are drawn for ten MRI images that belong to a healthy patient. The image database belongs to Whole Brain Atlas website[1]. The images are chosen to be sequential and the values of PSNR are shown in figure 3.

[1] http://www.med.harvard.edu/AANLIB/home.html

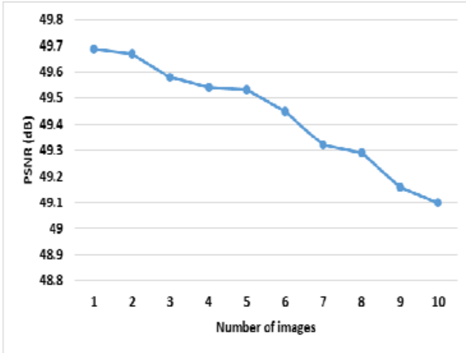


Fig.3. Value of PSNR (dB)

The PSNR is used as an image quality estimator after the watermarking process. The variation of PSNR is between 49.1 and 49.69. It decreases when the scanned images move to the superior part of the head in horizontal plane. These images have a smaller gray pixels area and a higher black area. An increase of the PSNR values is observed in figure 3, a higher value of PSNR reflects a good embedding of watermarking key.

CONCLUSIONS

The experimental results show that the proposed watermarking scheme embeds more correctly the information when the images contain a large gray area. For this type of images PSNR>40 dB, the watermarking process hides better the information. The DWT and the Gaussian noise embed the edges and textures and make the watermarked image safe and imperceptible. The proposed watermarking scheme can be used to protect the medical images and in the future can be developed a watermarking process that implies the encryption of physician’s signature.

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