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A new system for watermarking based on the turbo-codes and wavelet 5/3

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Abstract. *In order to contribute to the security, transmission and sharing of medical data between hospital centers, we propose a watermarking scheme for hiding medical information, specific to the patient, in the host image [1]. In this regard, the watermark consists of inserting data (usually binary data) in media (image in our case) and try to find these data with maximum fidelity, after applying various attacks [2]. The principal goal of our proposal is the conservation of psychovisual quality of the image, on the one hand, and the extraction of the different data inserted in another side. The robustness of the proposed scheme is tested against various attacks such as JPEG compression, adding noise, and filtering.*

Keywords. *Watermarking, JPEG compression, Security, Medical data.*

1. Introduction

In our current societies, digitization of multimedia content is widely used, their distribution is very broad. As a result of unsafe sharing these contents are easily modified. In these conditions, the copyrights might not be respected and the risk of falsifying the contained multimedia has become greater.

Furthermore, medical tools for analysis and diagnosis have seen a great evolution that requires the secure sharing of medical data between different hospitals centers.

From these situations, the results motivate of researchers to work on multimedia systems integration. This results in a compelling need to protect shared folders on the Internet and to protect the integrity of documents.

Digital watermarking [3] [4] [5] is an answer to this need, it is to integrate information in a digital document to ensure its safety. In our case the information is hidden patient-specific data in a medical image.

In this paper we present a new watermarking scheme can maintain the quality of the transferred image and integrity of information submitted after the application of many attacks.

The proposed watermarking system based on wavelet 5/3 in multi resolution.

On the other hand, the information will insert beings encoded using a powerful ECC is the serial turbo-code. This code must be able to correct the errors on the inserted information, which can be caused by possible distortions during image transmission.

The purpose of this method is to keep the integrity of the information included in medical diagnostic images by increasing the correlation between the extracted messages and decoded and the original signature before encoding. The image must retain its quality after insertion of medical information.

The evaluation of the quality of images made using PSNR and wPSNR.

2. Overview of the proposed system

In our watermarking method, we propose to insert data in the horizontal, vertical and diagonal detail with the wavelet decomposition of medical images.

The advantages of the proposed approach are the intervention of the error correction codes (ECC). We have chosen serial turbo-code for the ECC, whose goal is to improve augmentation rate checking and the correction, when possible, of the inserted information. Figure 1 illustrates the various data to be inserted.

The watermark is constituted with:

PATIENT RECORD
Hospital center
Patient Ref
Name of the doctor
Age
Adresse
Case History:
Date of admission
Diagnosis

Fig. 1. Data patient to insert.

For the preservation of the quality psychovisual image, we chose to Insert data in the corners of type L, T or Y, hence the necessity of the Harris algorithm.

In this paper we first present the details of the serial Turbo-code, Harris corner detector and the wavelet transform 5/3.

2.1 Error Correcting Code, Serial "Turbo-code"

The concept of Turbocode, recently introduced, is approximated to the notion of concatenation of many types of Error Correcting Codes. Indeed, a turbocode is to

concatenate two or many ECC generally convolutional separated by an interleaver block. Recalling that a convolutional code is to consider data as an infinite sequence of symbols that must go through a number of memory equal to $m+1$ on the way to generate a sequence of coded symbols. For the serial "Turbo-code", the idea is to concatenate two or many convolutional codes in series. These codes are usually separated by an interleaver block. This architecture allows course to break the error packets whose origin is within the decoder in order to facilitate the work of the other decoder said "Exterior".

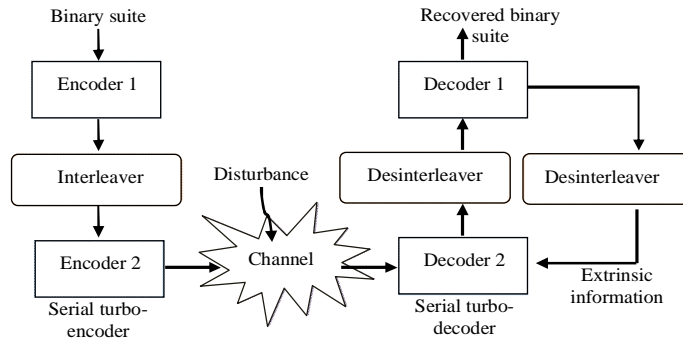


Fig. 2. Serial "Turbo-code" diagram.

The extrinsic information presented in the diagram above refers to a data set called data of reliability. It is exchanged between the decoders at the end of the correction to improve over the iterations [6].

2.2 Harris Corner Detector

In [7] Bas and al. evaluate the performance of three commonly used detectors (Harris Corner Detector [8], The Achard-Rouquet detector [9] and The Suzan detector [10]) and conclude the Harris Corner Detector is the most robust.

If $I(x,y)$ is the gray level intensity, the Harris corner detector refines the detection function [7] by using the following shape factor-based matrix M :

$$M(x, y) = \begin{bmatrix} A_{x,y} & C_{x,y} \\ C_{x,y} & B_{x,y} \end{bmatrix} = \begin{bmatrix} \left(\frac{\partial I(x, y)}{\partial x} \right)^2 & \left(\frac{\partial I(x, y)}{\partial x} \right) \left(\frac{\partial I(x, y)}{\partial y} \right) \\ \left(\frac{\partial I(x, y)}{\partial x} \right) \left(\frac{\partial I(x, y)}{\partial y} \right) & \left(\frac{\partial I(x, y)}{\partial y} \right)^2 \end{bmatrix} \quad (1)$$

Where $\frac{\partial I(x, y)}{\partial x} \approx I(x, y)[-1, 0, 1]$, $\frac{\partial I(x, y)}{\partial y} \approx I(x, y)[-1, 0, 1]^T$ with "*" denotes the convolution product.

The corner points are located at the positions with large corner response values, which are determined by the corner response function $R(x,y)$:

$$R(x, y) = \det(M(x, y) - k [\text{trace}(M(x, y))]^2) \tag{2}$$

$$R(x, y) = \left(A_{(x,y)} B_{(x,y)} - C_{(x,y)}^2 \right) - k \left(A_{(x,y)} + B_{(x,y)} \right)^2 \tag{3}$$

Where k is a constant defined according to Harris, $k=0.04$.

2.3 Multi-resolution Approach

As shown in Figure 3, the multi-resolution consists in presenting an image in several levels of resolution [11]. Given the original image I , and after N level decomposition, we will get two spaces:

The first named D-Space which corresponds to the details space ($D_1, D_2, D_3, \dots, D_N$). This space is obtained by extracting the high frequencies from the initial image.

The second space named A-space is the approximation space ($A_1, A_2, A_3, \dots, A_N$), it represents the lows frequencies signals extracted from the original image I .

Each image from the N levels-image and belonging to one of the preceded spaces, corresponds to a defined frequency-band image level.

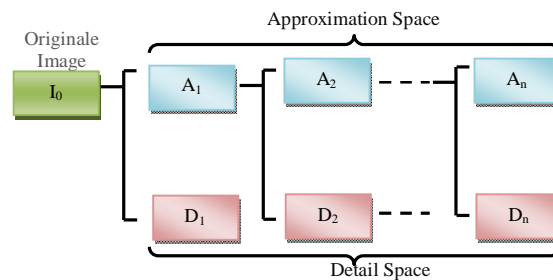


Fig. 3. Principe of multi-resolution approach.

2.3.1 Contribution of Wavelet 5/3

Wavelet 5/3 permits to work in the multi-resolution domain instead of the spatial domain [12]. They are based on the use of two types of filters, the first is a 5 order high-pass filters and the second is 3 order low-pass filters.

Indeed, this type of wavelet requires a short computing time. These wavelets are reversible, conservative and frequently used in the JPEG2000 standard [13].

The equations of decomposition and reconstruction wavelet 5/3 are as follows:

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Decomposition:

$$d[n] = d_0[n] - \left\lfloor \frac{1}{2}(s_0[n+1] + s_0[n]) \right\rfloor \quad (4)$$

$$s[n] = s_0[n] + \left\lfloor \frac{1}{4}(d[n] + d[n-1]) + \frac{1}{2} \right\rfloor \quad (5)$$

With:

$S_0[n]=X[2n];$
 $d_0[n]=X[2n+1];$
 $X:$ input signal.

Reconstruction:

The image reconstruction is based on the use of the application of the following two equations called twice GALL [13]:

$$d_0[n] = d[n] + \left\lfloor \frac{1}{2}(d[n] + d[n-1]) \right\rfloor \quad (6)$$

$$s_0[n] = s[n] - \left\lfloor \frac{1}{4}(d[n] + d[n-1]) + \frac{1}{2} \right\rfloor \quad (7)$$

3. Proposed watermarking algorithm

Our watermarking scheme is divided into two steps:

3.1 Insertion step

1. Compute the hospital signature center using SHA-1 as a hash function.
2. Concatenate the signature that contains the patient-information and diagnostic data. These data will be transformed into binary message and encoded using the serial turbocodes.
3. The standard JPEG2000 is the fifth level of decomposition, but in the insertion stage we stop at the second level of the decomposition in order to increase the insertion capacity. And then, we extract the 3 bands of details (horizontal, vertical and diagonal).
4. Using the Harris corner detector, the different parts are selected. These corners are frequently wedges L, Y or T.
5. Having the secret key, the visibility coefficient α and the pixel data carrier, insertion is done using the following formula:

$$Y_i = X_i + \alpha \times W_i \quad (8)$$

With

6. $Y_i:$ watermarked pixel

Xi: original image
 Wi : Data to be inserted

All of these steps are illustrated in the Figure 4.

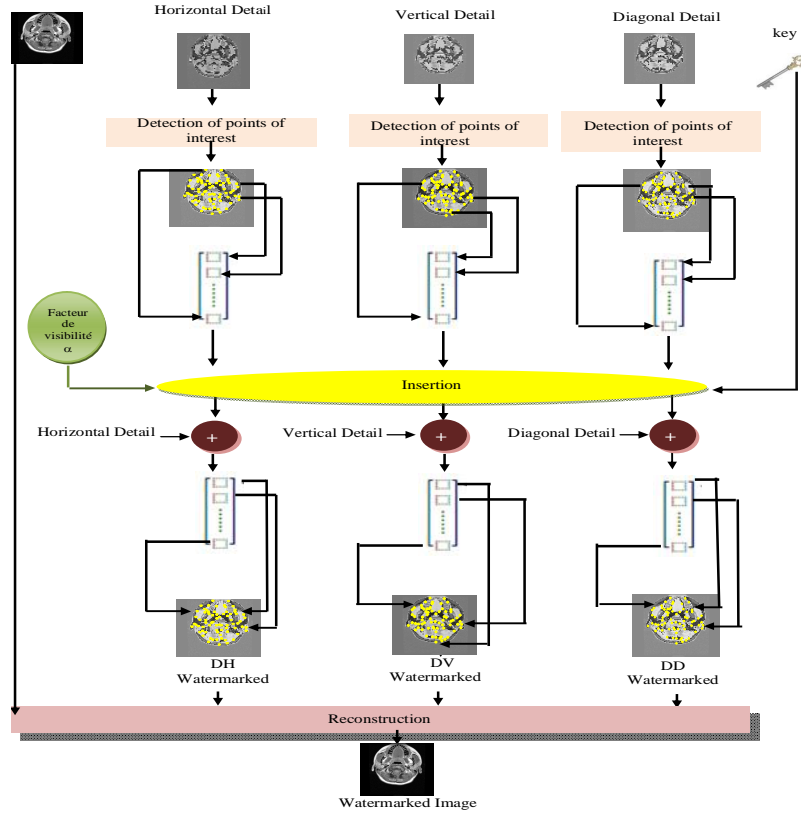


Fig. 4. Watermarked insertion algorithm.

3.2 Detection Step

In order to extract the data, use the inverse steps of the insertion phase is proposed. With the principal key, a same-sized image matrix is generated. Figure 5 illustrates the different steps.

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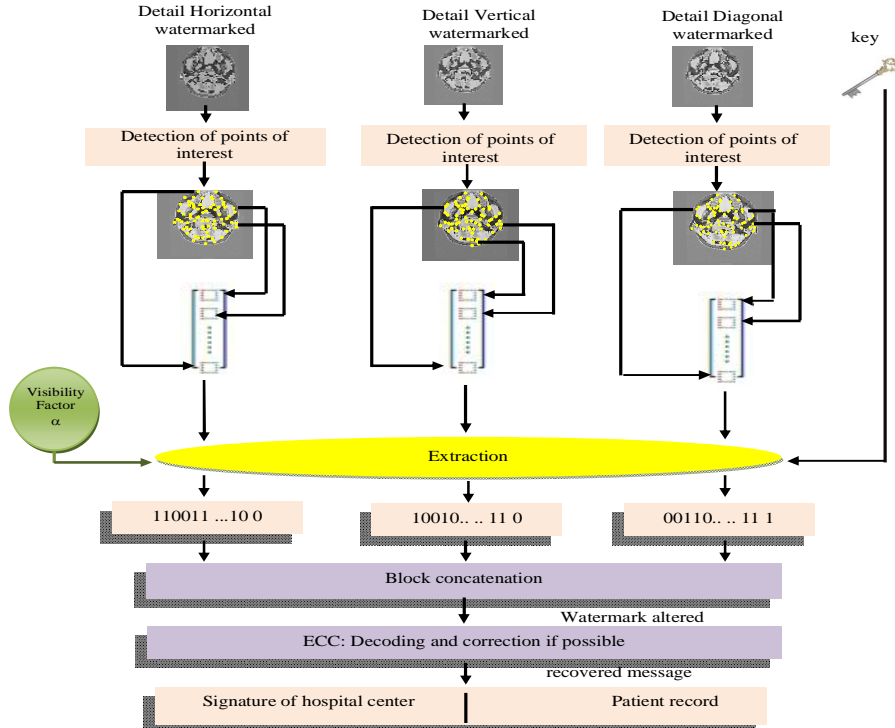


Fig. 5. Watermarked extraction algorithm.

4. Results and Discussion

The watermarking algorithm is evaluated with three kinds of images, namely IRM, Echographic, and Radiographic images.



Fig. 6. Test images

The size of the test images is 512×512. The signature used is that of Figure 1. The table shows the results of imperceptibility of the proposed algorithm using three objective measures:

1. PSNR (Peak Signal to Noise Ratio) and wPSNR (Weighted Peak Signal to Noise Ratio) calculated between the original image and the watermarked image.
2. AR (Accuracy Ratio) [14] calculated between the original signature and that extracted from the watermarked image.

The formulas that give the three objective measures are:

$$(PSNR)_{dB} = 10 \log_{10} \left\{ M \times N \frac{\max I^2(i, j)}{\sum_{i, j} [I(i, j) - I_w(i, j)]^2} \right\} \quad (9)$$

$$(wPSNR)_{dB} = 10 \log_{10} \left\{ \frac{M \times N \max I^2(i, j)}{\sum_{i, j} \left[\frac{I(i, j) - I_w(i, j)}{1 + \text{var}_I(i, j)} \right]^2} \right\} \quad (10)$$

$$AR = \frac{NCB}{TNB} \quad (11)$$

With:

NCB: Number of Correct Bits;

TNB: Total Number of Bits.

We note that the results obtained by measuring PSNR and wPSNR between the original image and the watermarked image are very good when we know that rate of the PSNR and the wPSNR are good value if they exceed 30dB.

Regarding the accuracy ratio, this algorithm permits to detect the totality of the message inserted in the tested images, AR=1.

Table 1. Rate imperceptibility and robustness of the watermark without application of attacks.

Image	PSNR	wPSNR	AR
Echographic image	49.1936	69.7958	1
Radiographic image	49.7684	69.7469	1
IRM image	49.6953	68.5357	1

To test the robustness of our algorithm we used multiple attacks.

The selected attacks are the most common and have been used with different parameters to properly test the robustness of the algorithm are presented in Table 2.

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Table 2. Attacks used for testing.

N° of attack	Attacks	parameter
1	JPEG attacks	Rate = 90
2	JPEG attacks	Rate = 70
3	JPEG attacks	Rate = 50
4	Impulsionnel noise attack : Salt & Pepper	Density = 0.001
5	Impulsionnel noise attack : Salt & Pepper	Density = 0.005
6	Impulsionnel noise attack : Salt & Pepper	Density = 0.009
7	Gaussian noise attack	Variance = 0.001
8	Gaussian noise attack	Variance = 0.005
9	Gaussian noise attack	Variance = 0.009
10	Median filter	3 * 3
11	Median filter	5 * 5
12	Median filter	7 * 7
13	Median filter	9 * 9

Table 3 shows the PSNR, wPSNR and the AR measurement obtained after applications different attacks on different images. The observation results (PSNR, wPSNR and AR) provides that the proposed algorithm is robust against various attacks.

Table 3. Results robustness under various attacks image.

N°	IRM			Echographic			Radiographic		
	PSNR	wPSNR	AR	PSNR	wPSNR	AR	PSNR	wPSNR	AR
1	45.777	64.102	1	41.340	63.174	1	41.990	63.291	1
2	43.424	55.829	1	37.888	55.318	0.998	37.572	55.179	1
3	33.783	51.314	0.999	36.178	51.537	0.980	35.317	51.296	0.996
4	33.937	49.089	1	35.134	50.313	1	34.321	49.478	1
5	27.019	42.122	1	28.399	43.546	1	27.446	42.559	1
6	24.281	39.340	1	25.829	40.951	1	39.786	24.692	1
7	31.156	44.662	1	30.010	45.081	1	30.043	45.141	1
8	24.460	37.464	1	23.071	38.113	1	23.386	38.411	1
9	21.997	34.800	1	20.542	35.586	1	21.104	36.014	1
10	31.579	45.685	1	33.008	47.039	0.998	28.864	41.818	1

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11	27.045	37.410	0.996	28.509	39.100	0.997	23.117	33.03	0.997
12	24.876	33.277	0.994	26.840	35.586	0.979	21.147	29.489	0.990
13	23.399	30.759	0.990	25.594	32.959	0.976	20.384	27.840	0.980

5. Conclusions

This paper present a digital watermarking system has greater robustness against various attacks.

This robustness is obtained by using the wavelet transform (insert space), use of the Harris corner detector (data integration in the corners) and the use of ECC (provided for the proper reception of data).

The wavelet used in this paper is the Wavelet 5/3 in goal to ensure robustness against compression attack.

For verifying and correcting if possible, the serial turbo-codes is used.

This method is perfectly suited to medical imaging because it benefits from the use of many algorithms in order to win, on the one hand, the quality of the image. On the other hand it ensures the extraction of all data (patient's own) thanks to ECC.

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