Use of Multi-Watermarking Schema to Maintain Awareness in a Teleneurology Diagnosis Platform

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Abstract. *Following the tremendous evolution of transferring images through the Internet, it is necessary to ensure security during this act and mainly for medical images.*

The application of multiple watermarking technique represents a solution to preserve the security of this data, on the one hand, and the traceability of medical diagnoses made by doctors, on the other hand. This falls under remote collaborative work. This technique is applied in the TeNeCi (Collaborative tele-neurology) platform. This project allows practitioners to distribute the analyses of the medical image. In fact, we used the multiple watermarking technique in a wavelet field. The theory underlying this technique is to hide information in the medical image and to ensure at the same time its imperceptibility. The diagnosis made by the practitioner is the inserted data in the image. The fundamental challenge of this paper is how to hide the total diagnoses of each practitioner in the image ensuring a good quality of the image at the same time.

Keywords

Multiple watermarking, medical images, TeNeCi project, wavelet transform, traceability.

1. Introduction

In the recent years, the number of internet users has increased. Such an increase is automatically accompanied by a growing threat against piracy and consequently the insecurity of messages. In the medical field, however, the transfer of images must be protected against piracy [1]. Indeed, the doctor uses the Internet as a means to exchange views with his/her colleagues in order to save time but this communication can be interfered or interrupted by a third person, which would lead to a change in the content of the image or to substitute one medical image by another.

The cooperative application incorporates various domains including networks, distributed systems, multimedia and data consistency. It is therefore useful to make a platform combining the functionalities common to all types of cooperative applications. The TeNeCi project is a platform that establishes an expert solution and support in neurological decision-making and in emergency neurology management. We develop an approach on multiple watermarking in the wavelet field to guarantee a record of the diagnoses.

In this paper, we apply a multiple watermarking technique in wavelet field to preserve the traceability and the record of the medical image diagnosis.

In the second section, we present the TeNeCi project.

In section 3, we specify the different constraints of the watermarking technique in wavelet domain.

In section 4, we expose our multiple watermarking technique used to preserve the security and the traceability of medical diagnoses made by doctors.

In section 5, we provide simulation results about our technique.

Finally, in the last section we comprise some concluding remarks.

2. TeNeCi platform Description

TeNeCi [2] (Collaborative tele-neurology), is a European project created between the CHU of Besançon (France) and the CHU Vaudois of Lausanne (Switzerland) in order to conceive and to develop a platform to establish and develop an expert solution and support in neurological decision-making and in emergency neurology management [3]. Figure 1 illustrates the based function of this platform and shows the analyses of the neurology image.

Fig.1. TeNeCi Platform

The TeNeCi project contributes to a better organization of the management of neurology emergencies thanks to the development of new techniques, which assist in emergency neurology diagnosis and treatment as well as in the field of neurological pathologies as a whole. These new techniques operating through a telecommunication network provide practitioners with real-time remote access to relevant information [4].

Medical decision-making is thereby facilitated thanks to the cooperative nature of the application. This aspect will contribute to real-time group-based work.

The use of the collaborative work doesn't stock all the diagnoses in the debate thus we have a record problem. For this reason, we elaborate a multiple watermarking approach that ensures a record for these diagnoses.

3. General context

Our method consists of inserting an invisible signature in a medical image. This signature can be, a text, a drawing on the image by the addition of an arrow for example or actions on the image itself following a change of contrast or luminosity. Indeed, a doctor is brought to work on the image and the platform undertakes to transmit the modifications to another doctor. This last recovers the handling of the preceding doctor and gives him his comment and so on. Hence, we obtain the multiple watermarking.

We note that this method can offer a record to the medical image of the patient and give precise report on the medical image since it can be under the control of a medical team. Indeed, each doctor is responsible for all the comments provided in the debate since they will be carried and under the judgement of all the speakers. Consequently, the doctor assumes the whole of the actions of which he is the author, and they will be filed in the medical image.

The application of the multiple watermarking technique ensures that each doctor inserts his diagnosis in the medical image without degrading it. With any new insertion, the image must always keep its clarity and its characteristics.

In a virtual ring, collaborative work between the experts lies in the fact that they share the analysis of a medical image among them thus allowing an exchange of information to enhance their knowledge and to diagnose well the medical image within a short time shown in figure 2.

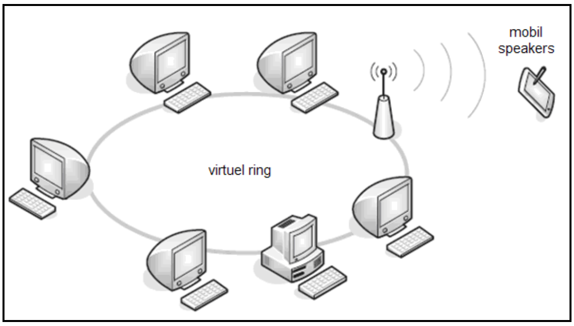

Fig.2. Collaborative work between doctors

The basic idea of the use of the multiple watermarking approach in this work lies in the fact that all the doctors are able to insert their diagnoses in turn while preserving the traceability of each one. The principle of insertion of the diagnoses is carried out in 4 phases:

- Phase 1: The medical image that will be treated must be available on the whole of the sites of the doctors.
- Phase 2: The doctors connected to the network are at the same time transmitters and receivers of information. Each doctor extracts and analyzes the other comments and delivers his own opinion.
- Phase 3: Each site receives the watermarked medical image of the previous doctor in the ring and extracts the comments to show it to the local doctor. This doctor visualizes it and inserts his own work. This stage is repeated throughout the course of the token (single message) around the virtual ring.
- Phase 4: At the end of the debate the diagnosis is safeguarded. It includes all the operations corresponding to each doctor and summarizes the final report of the treated medical image. This technique is based on multiple insertions on the same medical image.

Approach Constraints

- In the medical field, the embedded signatures mustn't modify the medical information contained in the image and mustn't affect the image quality.

- Since we applied our approach on the medical field, doctor doesn't allow any falsification and modification in the medical image. So, the least modification can influence the patient diagnosis (inserted signature). For this reason we must use a conservative wavelet transform.
- The underflow and overflow phenomenon [5][6] can be considered as a potential problem. Figure 3 explains the problem caused by this phenomenon.

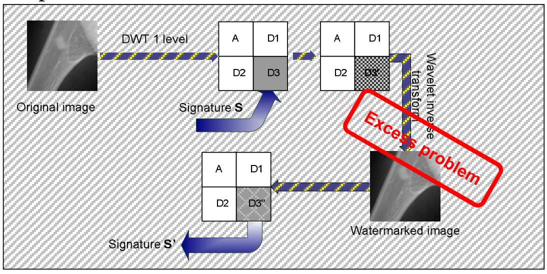

Fig.3. Excess problem

When we apply the inverse wavelet function, we notice that there are some pixels that will be over 255 and some others that will be less than 0. Indeed, each value exceeding the maximum of 255 takes the value 255 and each value less than 0 takes the value 0. Accordingly during the extraction phase we cannot find the signature inserted.

From these constraints, is born the need for introducing new multiple watermarking technique which surmount the precedent constraints.

4.Our Multiple Image Watermarking Scheme

Wavelet transform constitutes one of the newest topics in the image processing field [7].It offers a good temporal and frequency localization. This transform decompose image into sub bands at different resolution levels as shown in figure4.

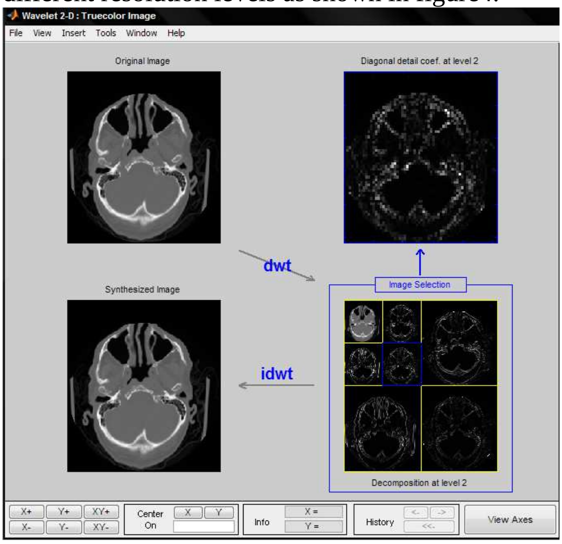

Fig. 4. Decomposition of the image using wavelet transform

The 5/3 wavelet transform is used in this work since it presents a conservative character.

In fact, by applying this transform on an image we can find it by application of wavelet inverse transform without appearance of any loss.

The forward equations for the conservative 5/3 transform are given by:

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

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

x [n], s[n] and d[n] are respectively the input signal, low pass subband signal and high pass subband signal.

We also define the quantities $s_0[n]=x[2n]$ and $d_0[n]=x[2n+1]$

Another advantage of this transform is the superior modeling of HVS (human visual system). In our technique we use special effect of the HVS that the human eye is less sensitive to change of higher image frequencies [8], this HVS characteristic is used to embed signature imperceptibly in the less significant coefficients.

To surmount the underflow and the overflow problem caused by the insertion of the diagnosis patient in the transformed coefficient; we will apply a dictionary to code the diagnosis. In fact the adopted coding technique is to reduce coefficient. The used formula is the following:

$$X = ASCII(x) - \alpha \qquad (3)$$

With: α : parameter

x: The original diagnosis letter.

X: The value after conversion.

After an empirical study, in this paper we used α = 96, and we obtain a dictionary to convert each character in a new value. Table 1 presents an example to clarify the dictionary.

Diagnosis	With out dictionary	With Dictionary
p	112	16
a	97	1
t	116	20
h	104	8
o	111	15
l	108	12
o	111	15
g	103	7
y	121	25

Tab.1. Conversion of the diagnosis

4.1. Insertion of the signature

The procedure of inserting of the signature is made as follows:

- The doctor writes his/her report after the examination of the patient.
- We apply the wavelets transformation to the medical image; we shall have 4 plans (a plan of weak frequency which contains the estimate of the image and three plans of details).
- The report is going to be converted by applying the approach developed to surmount the problem of overflow.
- The report is inserted into the image (the zone of higher frequency)
- We apply the inverse wavelet function transform [9] to have the watermarked image eventually.

Figure 5 explains the principle of the insertion of the signature.

$$PSNR = 10\log_{10}(\frac{X^2_{\max}}{MSE}) = 10\log_{10}(\frac{255^2}{MSE})$$

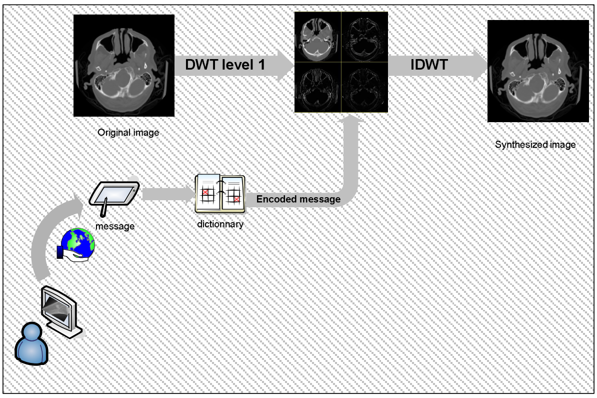

Fig. 5. Insertion phase

4.2. Extraction of the signature

The procedure of extraction is made in the same way as the procedure of insertion.
In the first time, we have to recuperate the coded diagnosis located in the high frequencies of the image and to resort the hidden data.
The stages of extraction are made as follows:

- we apply the wavelets transformation on the watermarked image.
- we extract the possible signature of the plan of high frequencies.
- we cross the signature to the dictionary so that the second doctor gets back the signature inserted by the previous doctor.

Figure 6 shows the stages of the procedure of the signature extraction.

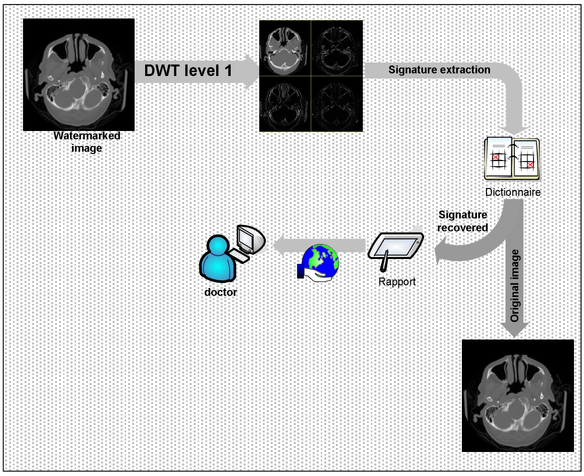

Fig. 6. Extraction phase

The second doctor extracts the diagnosis drafted by the previous doctor to give his notice of consent or refusal. This approach allows to enrich the knowledge of doctors to ensure a diagnosis sure of the medical examinations.
In our method we verify the comprehensibility of the extracted signature (doctor diagnosis) and if the message is not comprehensible, the watermarked image was considered as an altered image and it was rejected. So, our target is to guarantee the traceability and the record of the diagnoses.

5. Experimental study

In our experimental study, we tested 40 gray-scale images of 256x256 pixels that had been saved in BMP format. The images had been acquired from the DICOM standard.
The insertion would be in an invisible way and only the receiving doctor would be able to detect the signature correctly.
Figure 7 presents the original image and watermarked image after the insertion phase of the diagnosis using the described method.

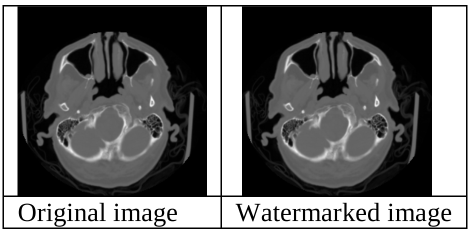

Fig. 7. Watermarked image

The addition of signatures to the medical image has given no modification or change with regard to the original, this means that visually the watermark is imperceptible and does not appear in the image. To analyze better this phenomenon, we used the metrics PSNR [10] defined as:

$$PSNR = 10\log_{10}(\frac{X^2_{\max}}{MSE}) = 10\log_{10}(\frac{255^2}{MSE}) \quad (4)$$

Where, X_{max} is the maximum luminance in the image.
The MSE (Medium Square Error) is used to quantify the distortion generated by the digital watermarking. In fact, we use an additive scheme to watermark the image. This modification could affect the quality of the image.

$$MSE = \frac{\sum_{i=1}^{n}\sum_{j=1}^{m}\left(I_{ij} - I_{ij}^{*}\right)^{2}}{nm} \quad (5)$$

Where, I and I* are respectively the original image and the watermarked one.
Indeed, the variation of the PSNR suite with care of the multiple watermark [11] in the field of wavelets is illustrated in figure 8.

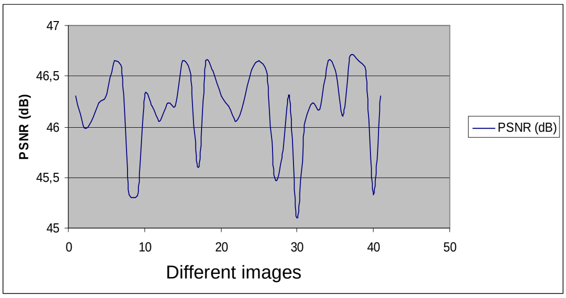

Fig. 8. PSNR variation

The PSNR metric is used to determine the degradation of the quality of the image after the insertion of the signature.

The medical images can undergo numerous transformations during their transmissions thus altering the information contained in the image. The doctors avoid working with examinations which are attacked and exclude any types of attacks [12]. Therefore, we should be interested in the fact that our developed approach must be sensitive to hostile or innocent attacks. Table 2 illustrates different manipulations taken in the simulation:

- Histogram equalization.
- Gaussien noise with a variance of 0, 02.
- Unsharp filter with α =0.5.
- JPEG compression with compression quality 70%.
- Rotation 2°
- Median filter [3x3]

		Inserted message: pathology	Extracted message
Without attacks		X	pathology
Attacks	Unsharp filter	X	Wh}q~hri`
	Gaussien noise	X	p tholi`išaZZ
	Median filter [3X3]	X	^a` a``b a_b`a
	Rotation 2°	X	````_a``a``a
	Compression JPEG 70%	X	```````````````
	Histogram egalisation	X	a~Šwud

Tab. 2. Behavior of the approach against attacks in the field of wavelets

According to this illustration, we note that the application of any attack on any image generates a wrong message during the extraction stage. In fact, doctor is certain of the integrity of the transmitted image and every modification was detected in the extracted phase.

6. Conclusion

The discrete wavelets transform in is an analysis in sub-bands, the bi-dimensional sign is divided into 3 details sub-bands and one approximation sub-band. The most used method to calculate function in wavelets is the method of benches of filters. The 5/3 wavelet is used in our case owed to its reversible character. The problem is met, because during the insertion of signatures the coefficients of the transforming wavelets are changed during their transformation. The problem encountered that we are not going to recuperate the inserted signatures, and they will have overflow. With this effect, we used a code which allows overcoming problems. We have proposed an insertion and extraction phase then we validate our approach by experimental study. This work is applied in the European platform TeNeCi that is supported by the INTERREGIII association.

Acknowledgments

The authors extend their thanks both to the Besançon Institute of Information Technology (ISTI), for initiating this project and the European Union for financing this project as part of the

INTERREGIII program in collaboration with Swiss partners (Vaud University Hospital at Lausanne, and EPFL Lausanne).

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