ISSN 2047-3338

A New Watermarking Approach– Combined RW/CDMA in Spatial and Frequency Domain

S.Bekkouche,

University USTO. BP .1505 El M'Naouar, 31100 Oran, Algeria, Computer Science Department
sbekkouche2008@gmail.com

A.Chouarfia

University USTO. BP .1505 El M'Naouar, 31100 Oran, Algeria, Computer Science Department
chouarfia@univ-usto.dz

***Abstract*— In this report we study some watermarking methods and the comparison result of their combination, the first one is based on the CDMA (Code Division Multiple Access) in frequency domain DWT(Discrete Wavelet Transform) noted CDMA-DWT ,CDMA in DCT(Discrete Cosine Transform) noted CDMA-DCT and CDMA in spatial domain noted CDMA-SD and its aim is to verify the image authenticity whereas the second one is the reversible watermarking (the least significant bits LSB and cryptography tools) noted RW and the reversible contrast mapping RCM its objective is to check the integrity of the image and to keep the confidentiality of the patient data. A new scheme of watermarking is the combination of the reversible watermarking and the CDMA method on the field of spatial domain noted RW/CDMA-SD and second combination in frequency domain (DWT and DCT) domain noted respectively RW/CDMA-DWT and RW/CDMA-DCT to verify the three security properties Integrity, Authenticity and Confidentiality of medical data and patient information. In the end ,we made a comparison between these methods within the parameters of quality of medical images. Initially, an in-depth study on the characteristics of medical images would contribute to improve these methods to measurements have been done on the watermarked image to verify that this technique does not lead to a wrong diagnostic. The robustness of the watermarked images against attacks has been verified on the parameters of PSNR (Peak Signal to Noise Ratio), MSE (Mean Square Error), MAE (Mean Absolute Error) and SNR (Signal to Noise Ratio) which show that the resulting quality of combination watermarking method is good in DCT than in DWT and spatial domain.**

***Index Terms*– Reversible Watermarking, CDMA-SD, CDMA-DWT, CDMA-DCT, Integrity, Authentication, Confidentiality and Combination**

I. INTRODUCTION

WATERMARKING is a new technology which hopefully can help in that aim. Before applying watermarking techniques developed for medical imagery applications, it is important that the requirements imposed by medical image are carefully analyzed to investigate whether they are compatible with existing watermarking techniques. Different watermarking schemes have been proposed to address the problems of medical confidentiality protection and both origin and data authentication. In this work, a watermarking technique is adapted to provide the three properties of security authentication, confidentiality and the integrity of medical image and patient information. Image watermarking is the process of embedding into image specific information that helps establishing the ownership of the image. Watermarking techniques are divided in two categories.

Spatial Domain Watermarking, where the least significant bits is replaced with watermark, and Frequency domain watermarking, where the image is first transformed to frequency domain and then the low frequency components are modified to contain the watermark. Watermarking can be applied in frequency domain by applying transforms like Discrete Fourier Transform (DFT) [10], Discrete Cosine Transform (DCT) [11] [16] or Wavelet transform (DWT) [12] [13] [16].

This new technique based on combination the CDMA in DWT [1] [8] [9] [20] and the reversible watermarking noted RW/CDMA-DWT [2] [6] [8], the second combination the reversible watermarking (RW) and the CDMA in spatial domain [1] [3] [9] noted RW/CDMA-SD[8] and the third combination the reversible watermarking and CDMA in DCT domain [17] [18] [19] [20] noted RW/CDMA-DCT. In section 2 the new watermarking paradigm is presented as a well designed scheme for the medical field. We give the main functionalities of our security system based on the combination the reversible watermarking and the CDMA in frequency domain (DWT and DCT) and spatial domain. Finally, the experimental results are presented to validate the proposed scheme. The techniques used for the comparative analysis of watermarking process are CDMA-SD, CDMA-DWT, RW, RCM [14] [15], and the combination of CDMA-DCT and the RW.

II. THE PROPOSED TECHNIQUE

First methods either by applying the reversible watermarking technique on the medical image then using the CDMA communication method in spatial and the second

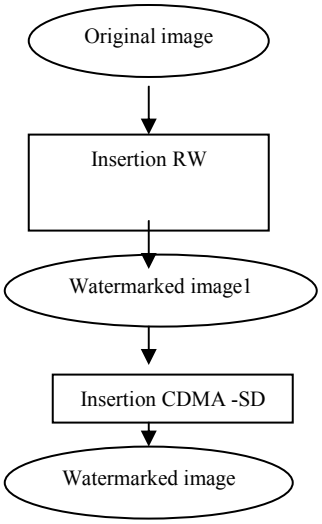


Fig. 1. Insertion RW/CDMA-SD

proposed method is the combination the reversible watermarking technique on the medical image then using the CDMA method in DWT domain**,** then consult the results of insertion and extraction steps and we test the performance against different types of attacks.

A. RW/CDMA-SD

By applying the reversible watermarking based on LSB bits and cryptography tools which give an image called watermarked image1, the CDMA-SD is applied to this image for given a final watermarked image.

1). Insertion process

The insertion RW/CDMA-SD has been shown in Fig. 1.

2). Extraction Process

- Using the step of the extraction CDMA process on the watermarked image.
- The result will be used as watermarked image1.
- Applying extraction reversible watermarking process on the watermarked image1 to extracting data from LSBs.
- Convert binary to ASCII to get to "@" character represents the end of the data inserted.
- Make a decoding key using the RSA inclusion K.
- Separate the footprint (size unknown) of Patient data and calculate the footprint of image to obtain the original ones.

The extraction process is shown below in Fig. 2.

B. RW/CDMA-DWT

By applying the reversible watermarking and CDMA in DWT domain.

1). Insertion Process

The insertion RW/CDMA-DWT is shown below in Fig. 3.

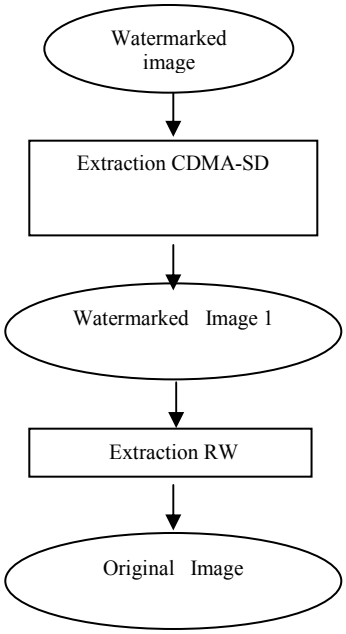


Fig. 2. Extraction RW/CDMA-SD method

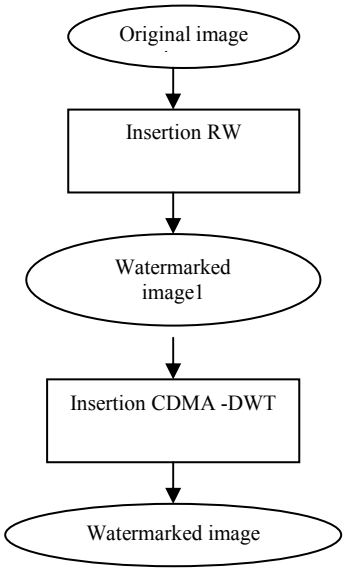


Fig. 3. Insertion RW/CDMA-DWT

2). Extraction Process

- Using the extraction steps of the CDMA method in DWT.
- Generation of multilayer sequence with the same key insertion K.
- Decomposition of the image with the DWT into a single resolution level.
- The result will be used as a watermarked Image
- Applying of extraction reversible watermarking method on the image result to get the original image. The extraction process is shown below in Fig. 4.

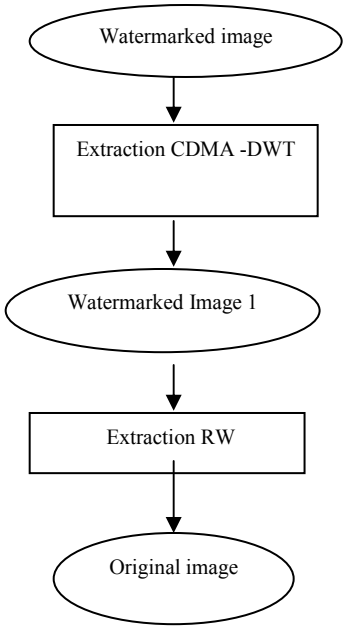


Fig. 4. Extraction RW/CDMA-DWT

C. RW/CDMA-DCT

By applying the reversible watermarking and CDMA in DCT domain.

1). Insertion Process

- The insertion process is the same of that of the insertion reversible watermarking process which gives the watermarked image1.
- Considering this result as a new input or a new original image using the original watermarking dominates the CDMA in DCT domain.
  - i. Process the watermarked image1 in blocks
  - ii. For each block
    - Transform block using DCT
  - iii. Move to next block until found the watermarked image

The insertion second combination is shown in Fig. 5.

2). Extraction Process

- Using the extraction steps of the CDMA method in DCT
- Process the watermarked image in blocks

For each block

- Transform block using DCT
- Process next block.
- Applying of extraction reversible watermarking method on the watermarked image1 to get an original image. The extraction process is shown in Fig. 6.

D. The Contribution of the Proposed Method ver the Methods Discussed

A comparison is made after achievement of the previous methods by comparing the all methods RW, RCM, CDMA-SD, CDMA-DWT, CDMA-DCT, RW/CDMA-SD

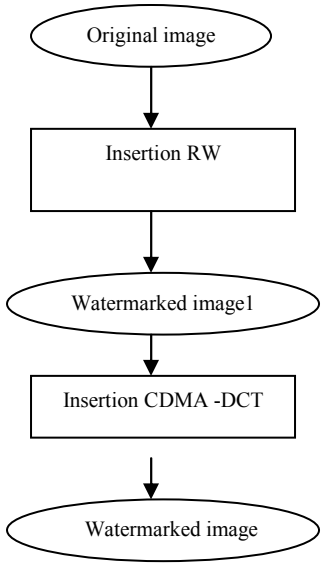


Fig. 5. Insertion RW/CDMA-DCT

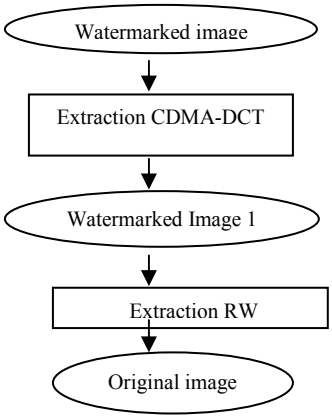


Fig. 6. Extraction RW/CDMA-DCT

RW/CDMA-DWT and RW/CDMA-DCT. All methods were applied on IRM medical image. The comparison is made according to parameters PSNR, SNR, MSE and MAE.

III. Implementation Details and Result

A. Test Images

An original bitmap image (256 x 256) is used**.** We have implemented eight algorithms and compared their results to investigate the performance of the algorithms based on PSNR values computed. The tests were performed for one type of medical images (IRM) coded on 256 gray levels, bmp format size 256x256.

Fig. 7 is an example of image used for testing. We conducted tests on 10 IRM medical images:

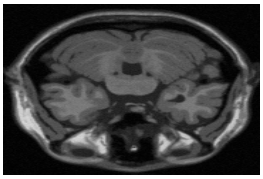


Fig. 7. IRM medical image

B. Insertion and Extraction Data

To insert the signature, the user must fill out the following input:

- *The signature:* to insert in the original image.
- *The key:* for hash the original signature.

Upon insertion, the user gets the number of bits in the signature. This data is necessary for the detection phase.

To detect the patient data the user must have:

- *The marked image:* to extract the signature.
- *The key:* for recover the original signature from the extracted signature.
- The number of embedded bits.

After the achievement of eight methods we compare them to evaluate the rate of evaluation of each it.

C. Discussion

The comparative analysis of the eight watermarking schemes has been done on the basis of noise and rotation attacks. Results of the individual watermarking technique have been compared on the basis of PSNR, MSE, MAE and SNR [4] given in equations (1) to (4).

Images having high PSNR value are preferable. For a good image the SNR value must be high.

$$MSE = \frac{1}{MN}\sum_{i}\sum_{j}(I(i,j) - I_w(i,j))^2 \quad (1)$$

$$MAE = \frac{1}{MN}\sum_{i}\sum_{j}\left|I(i,j) - I_w(i,j)\right| \quad (2)$$

$$PSNR = 10\log_{10}\frac{Xmax^2}{MSE} = \frac{255^2}{MSE} \quad (3)$$

$$SNR = \frac{\sum_{1}^{M}\sum_{1}^{N} I_s^2}{\sum_{1}^{M}\sum_{1}^{N}(I_e - I_s)^2} \quad (4)$$

Where $I(i,j)$ original image is I_w is watermarked image, M×N is the image size and x is the peak signal value of the original image.

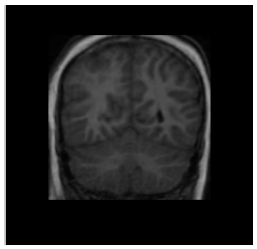
Table 2 shows that whatever the change in the size of the image, the PSNR value of the approach RW/CDMA-DCT still better than the value of PSNR of the method RW/CDMA-SD and RW/CDMA-DWT.

Table 1: Comparison between the six methods

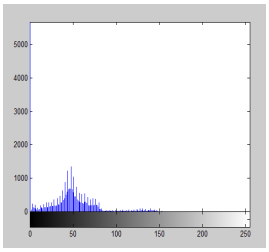
	PSNR	SNR	MSE	EAM	Properties of Security
RW	49.17	33.10	0.786	0.40	Authentification
CDMA -SD	40.50	24.43	5.79	2.34	Integrity and Confidentiality
CDMA - DWT	54.21	38.14	0.24	0.43	Integrity and Confidentiality
CDMA-DCT	76.71	60.64	0.0014	0.00062	Integrity and Confidentiality
RCM	54.83	38.70	0.213	0.40	Authentification
RW/CDMA-SD	39.37	23.29	7.56	2.47	Authentification, Integrity and Confidentiality
RW/CDMA-DWT	49.17	33.10	0.78	0.409	Authentification, Integrity and Confidentiality
RW/CDMA-DCT	75.76	59.76	0.00172	0.0009	Authentification, Integrity and Confidentiality

Table 2: Ccomparison between different methods for medical image IRM of different sizes

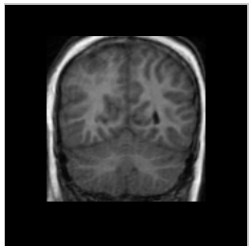
Méthode /taille	128x128	256x256
	PSNR (dB)	PSNR (dB)
RW	49.28	49.17
RCM	60.87	54.83
CDMA-SD	40.48	40.50
CDMA-DWT	54.21	54.21
CDMA-DCT	58.08	76.71
RW/CDMA-SD	39.37	39.37
RW/CDMA-DWT	49.16	49.17
RW/CDMA-DCT	69.74	75.76



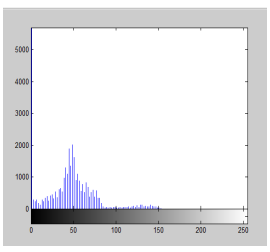
(a)



(a')



(b)



(b')

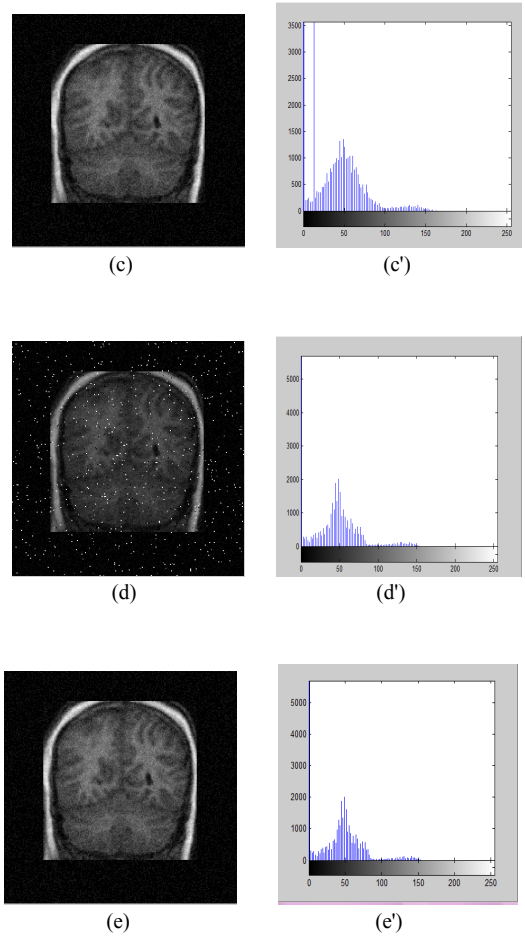


Fig. 8. (a) Original image, (a') histogram of original image,
(b) Watermarked image after RW,(b') Histogram of watermarked image after RW,
(c) watermarked image after RW/CDMA-SD , (c') Histogram of watermarked image after RW/CDMA-SD,
(d) Watermarked image after RW/CDMA- DWT, (d') Histogram of watermarked image after RW/CDMA- DWT,
(e) watermarked image after RW/CDMA-DCT, (e') Histogram of watermarked image after RW/CDMA-DCT.

From the Table 1 and Fig. 8, we see that the approach RW/CDMA-DCT is effective to insert a signature in the medical image without much visual degradation.

We also note that despite the change in the size of the image, the PSNR value of the approach RW/CDMA- DCT still better than the value of PSNR of the method RW/CDMA-DWT and RW/CDMA-SD.

D. Noise Attacks on Watermarked Image

The attack methodology on the watermarked image is based on the idea that an attacker does not have any access to the original image or the watermark image/signature. The attacks are, therefore, done on the watermarked image using only the watermarked image as input. The individual, i.e. attacker, likely has no idea if the attack worked or not so the results are not known to the attacker. With addition of salt and pepper noise, performance of watermarking scheme is analyzed.

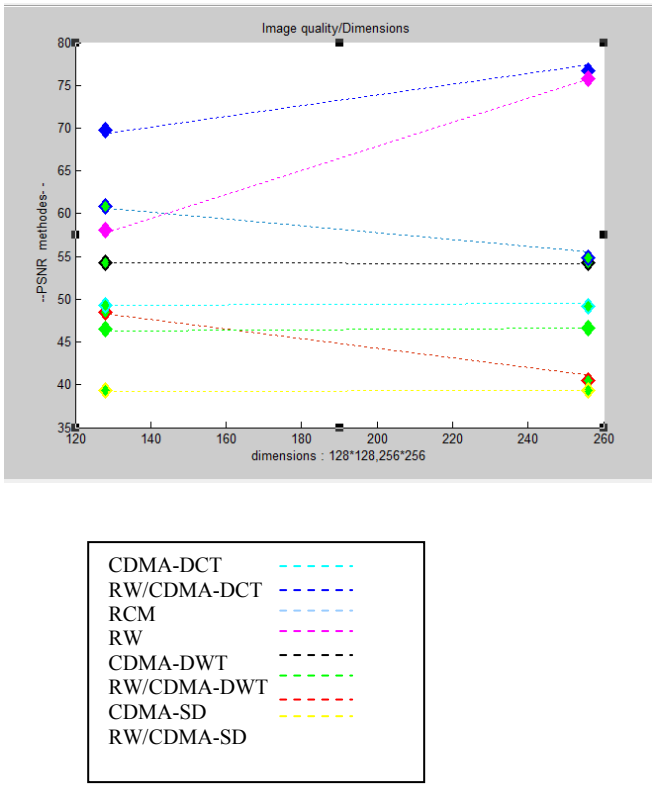


Fig. 9. Relation between size and image quality PSNR of different Methods

1). Salt and pepper noise

Fig. 10 (d), Fig. 11(d) and Fig. 12 (d), show the simulation results of watermarked image with salt and pepper noise at a gain factor of 0.02.

E. Results of Noise Attacks

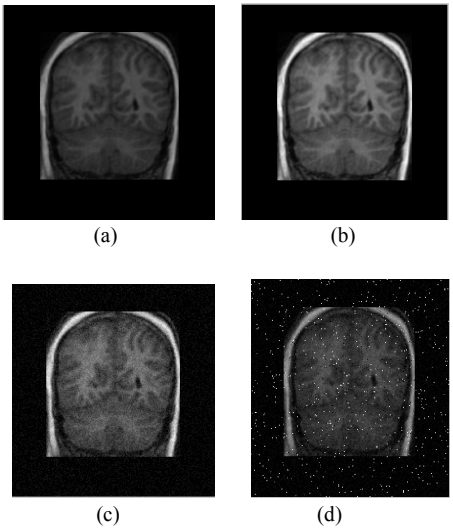
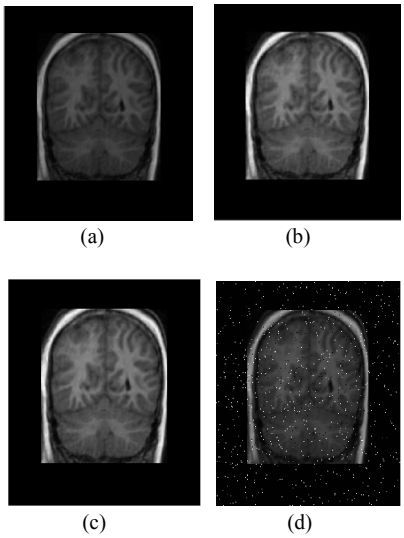


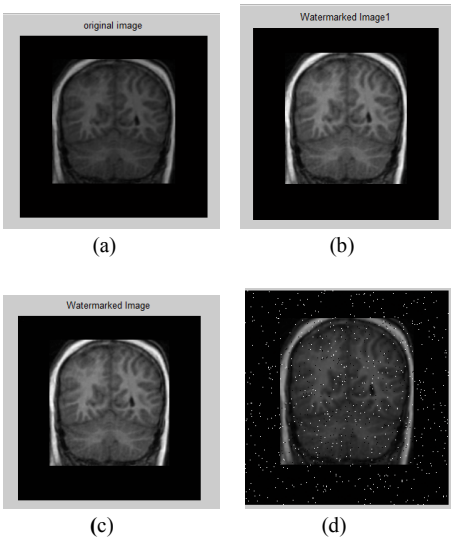
Fig. 10. RW/CDMA-SD: (a) Original image, (b) Watermarked image1 after RW, (c) Watermarked image after RW/CDMA-SD, (d) Noise Watermarked image



(a) (b)

(c) (d)

Fig. 11. RW/CDMA-DWT: (a) Original image, (b) Watermarked image1 after RW, (c) Watermarked image after RW/CDMA-DWT, (d) Noise Watermarked image



(a) (b)

(c) (d)

Fig. 12. RW/CDMA-DCT: (a) Original image, (b) Watermarked image1 after RW, (c) Watermarked image after RW/CDMA-DCT, (d) Noise Watermarked image

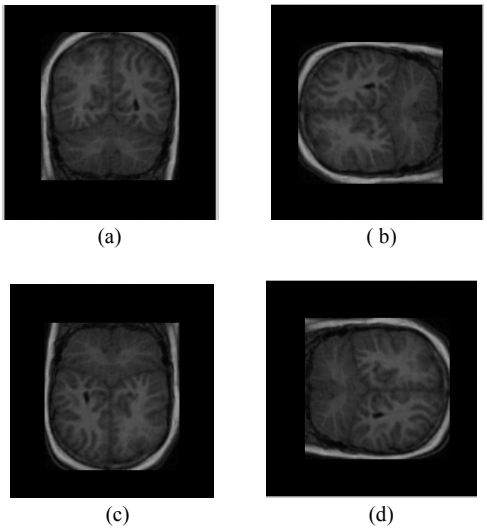
Table 3: The performance analysis against noise attack

Method	PSNR(dB)	MSE
RW	47.64	1.119
RCM	47.55	1.142
CDMA-SD	47.42	1.176
CDMA-DWT	47.77	1.085
CDMA-DCT	48.37	0.945
RW/CDMA-SD	47.35	1.194
RW/CDMA-DWT	44.48	2..315
RW/CDMA-DCT	48.34	0.952

The PSNR shown in Table 3 expressed in (dB) is calculated between the original image and noise watermarked image.

F. Results of Rotation Attack

Rotation attack is among the most popular kinds of geometrical attack on digital multimedia images [7] [5]. Three levels of rotation have been implemented. The original watermarked image is rotated by 90°, 180° and 270° in clock wise direction. Figure 13 and Figure 14 show the rotation attack. The Table 4 shows the results of the rotation attack for all the eight watermarking schemes.



(a) (b)

(c) (d)

Fig. 13. The rotation Attack: (a) Original watermarked image, (b) Watermarked image after 90° rotation, (c) Watermarked image after 180° rotation, (d) Watermarked image after 270° rotation

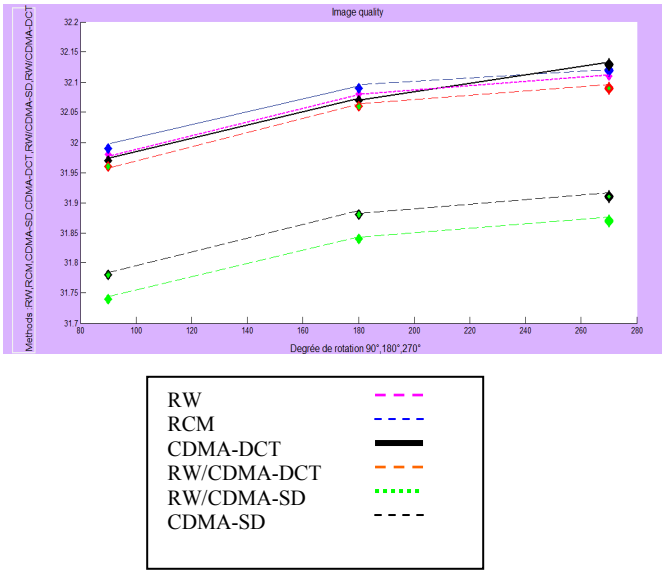


Fig. 14. Image quality PSNR of different methods for three levels of rotation

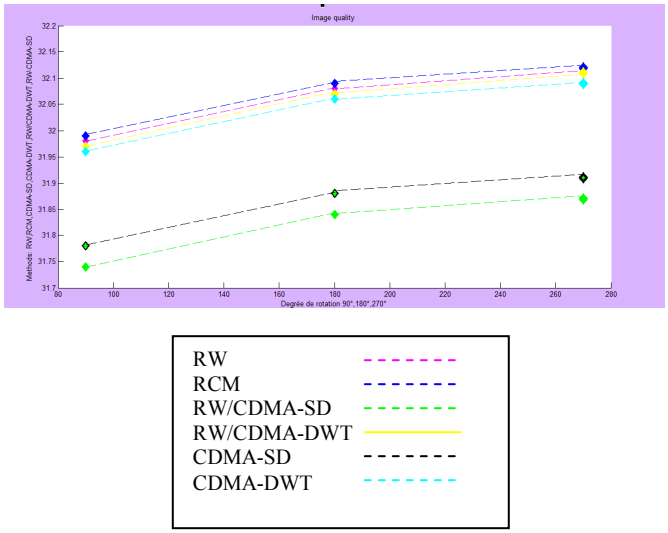


Fig. 15. Image quality PSNR of different methods for three levels of rotation

The PSNR values in Table 4, Fig. 14 and Fig. 15 show that the RW/CDMA-DCT technique has the greatest value for the PSNR value. This shows that the DCT domain watermarking is the best practice for the digital image watermarking purpose**.**

Table 4: The Performance analysis against rotation attack

Degré de roation/PSNR	**90°**	**180°**	**270°**
	PSNR	**PSNR**	**PSNR**
RW	**31.99**	**32.09**	**32.12**
RCM	**31.99**	**32.09**	**32.12**
CDMA-SD	**31.78**	**31.88**	**31.91**
CDMA-DCT	**31.99**	**32.09**	**32.12**
CDMA-DWT	**31.98**	**32.09**	**32.12**
RW/CDMA-SD	**31.74**	**31.84**	**31.87**
RW/CDMA-DWT	**31.98**	**32.09**	**32.12**
RW/CDMA-DCT	**31.99**	**32.09**	**32.12**

IV. Conclusion

This article proposed an efficient digital watermark scheme to increase security, Authentication, confidentiality and integrity of medical image and patient information, to transmit it via internet based on combining two watermarking techniques. First technique uses a reversible watermarking by combine the least significant bit and cryptography tools. Second technique uses the CDMA in frequency domain (DCT and DWT) and spatial domain.

The watermark can be used to introduce the patient's information in a private and sure manner all while preserving the visual quality of watermarked image.

The experimental results show that RW/CDMA-DCT is highly robust against several of image processing Operations such as salt and pepper noise. The simulation results shows that high quality image i.e. watermarked image with high PSNR is obtained by embedding the watermark in DCT domain than other techniques in spatial domain and DWT presented in this article. This paper focuses on the robustness of the watermarking techniques chosen from all the two domains of watermarking against rotation attack.

The conclusion of the paper is that the combination the RW and CDMA in DCT domain watermarking technique is the best and most robust scheme for the watermarking of medical images. This work could further be extended to the watermarking Purpose of another digital content like colored medical image TEP.

References

[1] Chris Shoemaker,"Hidden Bits: A Survey of Techniques for Digital Watermarking", Independent Study EER-290. Prof Rudko, Spring 2002.

[2] S.BOUCHERKHA & M. BENMOHAMED, A lossless watermarking based authentication system for medical image, In International Journal of Signal Processing, Vol.1, N°4, 2004.

[3] B.VASSAUX, Technique multicouches pour le tatouage d'images et adaptation aux flux vidéo MPEG-2 et MPEG-4, Thèse de Doctorat, Institute National Polytechnique Grenoble France, 2003.

[4] B. Aiazzi, L. Alparone et S. Baronti. "Near-lossless compression of 3-D optical data". IEEE Transactions on Geoscience and Remote Sensing. vol. 39, no. 11, p. 2547–2557, nov. 2001.

[5] Ping Dong, Jovan G. Brankov, Nikolas P. Galatsanos, Yongyi Yang, Franck Davoine,"Digital Watermarking Robust to Geometric Distortions", IEEE Transactions on Image Processing, Vol. 14, NO. 12, December, 2005.

[6] YongJie Wang, Yao Zhao, Jeng-Shyang Pan and ShaoWei Weng,"A Reversible Watermark Scheme Combined with Hash Function and Lossless Compression ", Volume 3682/2005, 1168-1174, DOI: 10.1007/11552451_161, computer Science, 2005.

[7] Harsh K Verma1, Abhishek Narain Singh2, Raman Kumar3," Robustness of the Digital Image Watermarking Techniques against Brightness and Rotation Attack", (IJCSIS) International Journal of Computer Science and Information Security,Vol. 5, No. 1, 2009.

[8] S.Bekkouche,A,Chouarfia ,"A new watermarking based on combination of reversible watermarking and CDMA in spatial and DW domain", International journal of security (ISJ), volume 5, issue 1.Avril 2011, Malaysia.

[9] Yhya. R. Kuraz, Modar A.H.,"Improve Watermark Security via Wavelet Transform and Cdma Techniques", Al-Rafidain Engineering Vol.16 No.3 Aug. 2008.

[10] Pranab Kumar Dhar, Mohammad Ibrahim Khan, and Jong Myon Kim1,"A New Audio Watermarking System using Discrete Fourier Transform for Copyright Protection", IJCSNS International Journal of Computer Science and Network Security, Vol. 10 Number 6, June 2010

[11] Xu Yan-ping, Jia Li-qin,"Research of a Digital Watermarking Algorithm Based on Discrete Cosine Transform Proceedings of the Third International Symposium on Electronic Commerce and Security Workshop (ISECS '10) Guangzhou P R China 29-31 July 2010, pp 373-375.

[12] Y.I. Khamlichi, M. Machkour, K. Afdel, A. Moudden, ' Medical Image Watermarked by Simultaneous Moment Invariants and Content-Based for Privacy and Tamper Detection', Proceedings of the 6th WSEAS International Conference on Multimedia Systems & Signal Processing, Hangzhou, China, April 16-18, pp109-113, 2006.

[13] W.T. Huang S-Y, Tan Y.J Chang and C.H. Chen, "A robust watermarking technique for copyright protection using discrete

wavelet transform", WSEAS Trans. Computers, vol. 9, no. 5, pp. 485-495, 2010.

[14] Yeh-Shun Chen, *Ran-Zan Wang, Yeuan-Kuen Lee, Shih-Yu Huang "Steganalysis of Reversible Contrast Mapping Watermarking", Proceedings of the World Congress on Engineering, Vol 1 WCE 2008, July 2 - 4, 2008, London, U.K

[15] Dinu Coltuc and Jean-Marc Chassery, "Very Fast Watermarking by Reversible Contrast Mapping", IEEE Signal Processing Letters, Vol. 14, Number. 4, 2007.

[16] Chi-Man Pun and Ioi-Tun Lam," Fingerprint Watermark Embedding by Discrete Cosine Transform for Copyright Ownership Authentication",INTERNATIONAL JOURNAL OF COMMUNICATIONs, Volume 3, Issue 1, 2009.

[17] Chen Xiaosu Zhang Zhiguang Yao Xiaofeng, "CDMA watermarking algorithm using WPT and DC"', Journal of Huazhong University of Science and Technology 2009.

[18] GAO Bao-jian,ZHAI Rui-ying,YANG Yan-ping ,'CDMA image watermarking algorithm based on DCT', Journal of Northwest University(Natural Science Edition)》 2007.

[19] Tribhuwan Kumar Tewari, Vikas Saxena,' An Improved and Robust DCT based Digital ImageWatermarking Scheme', International Journal of Computer Applications (0975 – 8887) Volume 3 – No.1, June 2010.

[20] Johnson C. Lee, Student Member,' Analysis of Attacks on Common Watermarking Techniques', IEEE Electrical and Computer Engineering Department Avril 2011.