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A survey on Reversible Watermarking Techniques for Medical Image

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Abstract**—** Recently Healthcare system becomes very much important in every days life. Medical images play an important role for clinical purposes and also for research of medical science. These images are very sensitive and can be modified easily with existing image processing tools. Faithfull recovery of these images is also very important for proper diagnosis. Some reversible watermarking can fulfill most of these requirements. In this paper we discuss some reversible watermarking schemes which are suitable for the medical imaging applications.

Keywords**—** Reversible Watermarking, ROI, RONI,SSIM,PSNR.

I. INTRODUCTION

Now in modern health care, systems like HIS (Hospital Information System) and PACS (Picture Archiving and Communications System) develop the information technology infrastructure for hospitals. Advancement in medical information system had changed the way of patient records storage, access and distribution. The records or medical images need to be protected from unauthorized modification or destruction of information. Recently various security measures used to protect the integrity of the patient records are such as VPN (Virtual Private Network), data encryption and data embedding. Data encryption is also being used on the Internet to protect sensitive data during its transmission and to protect medical images in the form of digital signature. The problem with digital signature is that it needs to be transmitted in a separate file with the image or in the image header. There is a risk of losing the signature during transmission. The signature will also can be lost if the image file is converted to another format. During data embedding the related information such as digital signature can be inserted into the medical images as a watermark. There is no standard of implementation and it is more difficult to be performed. But this technique offers advantages over VPN and data encryption. Reversible Watermark provides some objectives in medical images:

• watermarking by which important information is embedded to make the image secure and also for decoding purpose.

• Integrity control, to verify that the image has not been modified without authorization.

• Authenticity that is to verify that the image is really what the user supposes it is.

• Faithfull recovery that is to recover the cover image is in decoder side without loss.

In this paper, we aim to provide a review of watermarking schemes used in medical imaging.

Section I draws the introduction of the medical Images watermarking. In the section II requirements of medical image watermarking is discussed, watermarking in medical images will be discussed in section III. In the next section (Section IV) different types of domains for watermarking, then current watermarking techniques and schemes for the usage in medical imaging is discussed in section V. The sections VI discuss the Performance Measuring Parameters of those schemes. At last the conclusion is drawn in section VII.

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II. REQUIREMENTS OF MEDICAL IMAGE WATERMARKING TECHNIQUES

Medical information protection derives from strict ethics and legislatives rules. Regulations like USA's HIPAA and Europe's EC 95/46 Directive are expressions of such a constraint. Focusing on medical information records, which for a patient are a complex set of clinical examinations, diagnosis annotations and other findings and images centered in its EPR, we recall the three mandatory security characteristics:

• Confidentiality, which means that only the entitled users have access to the information;

• Availability, that is the ability of an information system to be used in the normal scheduled conditions of access;

• Reliability, based on the outcomes of:

i) Integrity - the information has not been modified by non-authorized people, and,
ii) Authenticity - a proof that the information belongs to the correct patient and issued from the right source.

III. WATERMARKING IN MEDICAL IMAGES

Before proceeding to the design of the watermarking scheme, the foundation of digital watermarking, types of domain and performance measurement methods is discussed in this section. Fundamentally, watermarking system is shown as in Fig. 1.
The encoder, E embeds the watermark, W inside original image I by using embedding function, E as shown in equation (1).

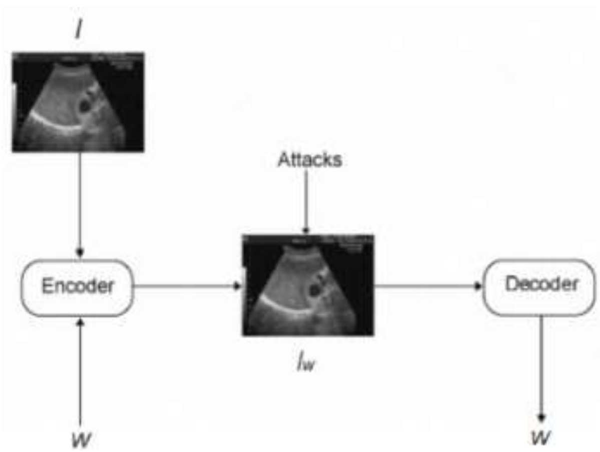

Fig. 1 Block Diagram of Watermark Encoding and Decoding

$$E(I,W) = I_W \quad (1)$$

The output from this process is I w, the watermarked image. The decoder, D will detect or extract the watermark, W from the watermarked image as in equation (2) [1].

$$D(I, I_W) = W \quad (2)$$

IV. TYPES OF DOMAIN

Watermarking techniques can be classified according to how the watermark is embedded namely within the spatial domain or in transform domains.

A. Spatial Domain:

One of the most direct and simple technique is to embed the watermark code into the LSBs (Least Significant Bits) of the image. Since a change in LSB corresponds a change in the unit of image gray value, its modification is not perceivable by human eyes. This techniques in this domain is not as robust as transform domain techniques and rarely survives various attacks.

B. Transform Domain:

Most of the transform domain techniques embed watermark information into the transform coefficients of the cover image. DCT (Discrete Cosine Transform), DWT (Discrete Wavelet Transform) and DFT Discrete Fourier Transform) are the three popular methods in this category. These methods require a longer computation time but they are compatible with the image compression and also more robust against geometric transformation such as rotation, scaling, translation and cropping etc.

V. LITERATURE REVIEW

Huang et al. [2] presents a reversible data-hiding scheme for medical images. This method uses three neighboring pixels to predict the current pixel. For the prediction error, two histograms, *h1*and *h2*,are generated. The distribution in histogram *h1* and *h2* is more compact. The algorithm intends to embed secret data into the cover image by using the modification of the two histograms *h1*and *h2* instead of the original image histogram. The proposed method has the advantages like the stego-images have good visual image quality and has a higher pure payload.

Tan et al. [3] presents a fully reversible, dual-layer watermarking scheme with tamper detection capability for medical images. This scheme utilizes the concepts of public-key cryptography and also the reversible data-hiding technique. The technique ensures the image authenticity and integrity, and also can locate tampered regions in the images.

Maity et al. [4] proposed a robust Reversible watermarking technique foe medical images based on region based technique. Here the medical image is partitioned in ROI and RONI portion first. Then embedding is done on ROI portion based on RCM algorithm. IWT based SS modulation technique is used for embedding in RONI portion.

Arsalan et al. [5] proposed an intelligent reversible watermarking approach GA-Reversible watermarking for medical images. GA-Reversible watermarking is based on the concept of block-based embedding using genetic algorithm (GA) and integer wavelet transform (IWT). GA based intelligent threshold selection scheme is applied to improve the imperceptibility for a fixed payload or vice versa. The scheme shows that GA-RW provides significant improvement in terms of imperceptibility for a desired level of payload against the existing approaches.

Hung et al. [6] proposed a histogram shifting method for image reversible data hiding testing on high bit depth medical images. Among image local block pixels, the high correlation for smooth surface of anatomical structure in medical images are exploited. Thus a different value is applied for each block of pixels to produce a difference histogram to embed secret bits. During data embedding, the image blocks are divided into two categories due to two corresponding embedding strategies. Via an inverse histogram shifting mechanism, the host image can be accurately recovered after the hidden data extraction.

Deng et al. [7] proposed a new region-based tampering detection and recovering method that utilizes both reversible digital watermarking and quad-tree decomposition for medical diagnostic image's authentication. The quad-tree decomposition is used to divide the image into blocks with high homogeneity. The pixels' linear interpolation is computed as each block's recovery feature. The scheme shows high embedding capacity and good visual quality of marked and restored image, but also has more accuracy for tampering detection.

Lei et al. [8] a new and reversible watermarking method is proposed to address this security issue. Specifically, signature information and textual data are inserted into the original medical images based on recursive dither modulation (RDM) algorithm after wavelet transform and singular value decomposition (SVD). In addition, differential evolution (DE) is applied to design the quantization steps (QSs) optimally for controlling the strength of the watermark. Using these specially designed hybrid techniques, the proposed watermarking technique obtains good imperceptibility and high robustness. Experimental results indicate that the proposed method is not only highly competitive, but also outperforms the existing methods.

Kumar et al. [9] propose a technique based on difference expansion, in which the transferred image consist of the original image embedded with, the patient information, hash of the original image and the payload required for the recovery. In order to provide confidentiality, the payload and the patient information both are encrypted using symmetric key based encryption algorithm, this provides that the patient information is confidential and the image too could not recovered for diagnoses under attack. Hash of the recovered image is calculated and compared with the recovered embedded hash to make sure that the image has not been tampered.

Phadikar et al. [10] proposed a reversible watermarking technique based on DE method in IWT domain. The watermark is embedded within the Integer wavelet coefficients using Tian's difference expansion technique. Lifting together with channel coding is used here for improvement of the detection performance of the extracted watermark bits.

Han et al. [11] proposed novel medical image digital watermarking algorithm in three-dimensional Fourier compressed domain. The algorithm takes advantage of three-dimensional Fourier compressed domain characteristics, Legendre chaotic neural network encryption features and robust characteristics of differences hashing. In order to enhance security the original watermarking image is encrypted. The watermarking algorithm can solve the problem of medical image content affected due to ROI selection. The specific implementation of the algorithm and the experimental results are given in the paper. The scheme is also robust against common and geometric attack.

Han et al. [12] proposed a new watermarking algorithm for medical volume data in sub-block three-dimensional discrete cosine transform domain. In this scheme original watermarking image is scrambled by a Chebyshev chaotic neural network for improvement of watermarking security. Sub-block three-dimensional discrete cosine transform and also perceptual hashing are used to construct zero-watermarking. Medical image distortion is controlled and geometric attacks can be restricted. The method shows good security, and robustness to various geometric attacks.

VI. Performance Measuring Parameter

In order to calculate the performance of the watermarked images, there are some performance measures such as ET, NCC, PSNR, MSE, and BER.
In order to calculate the performance of the watermarked images, there are some performance measures such as Execution Time (ET), Normalized Cross Correlation (NCC), Peak Signal to Noise Ratio(PSNR), Mean Square Error (MSE), and Bit Error Rate (BER) .

A. Execution Time (ET):

It is one of the important parameter to compute the working and performance of the watermarking algorithms in relation with time. It evaluates the amount of time required in embedding process and extraction process of watermark. To measure of execution time CPU cycles are used. General formulae can be used as:
Initial _time=CPU time
Time _Taken=CPU time-Initial time

B. Normalized Cross Correlation (NCC):

It is used to measure the similarity between the cover image and the watermarked image as well as original watermark and recovered watermark. Higher the value of NCC will result in better technique. It is calculated by the formula:

$$NCC = \frac{\sum i \sum j [I(i,j) - Iw(i,j)]}{\sum i \sum j [I(i,j) + Iw(i,j)]} \quad (3)$$

C. Mean Square Error (MSE):

It is defined as average squared difference between a reference image and a distorted image. It is calculated by the formula given below X and Y is height and width respectively of the image.

$$MSE = \frac{1}{W \times H} \sum_{i=0}^{W-1} \sum_{j=0}^{H-1} [f(i,j) - f'(i,j)]^2 \quad (4)$$

D. Peak Signal to Noise Ratio(PSNR):

It is used to find out the degradation in the embedded image with respect to the host image .It is calculated as:

$$PSNR = 10 \log_{10} \frac{(255)^2}{MSE} \quad (5)$$

L is the peak signal value of the cover image which are equivalent to255 for 8 bit images.

E. Bit Error Rate(BER):

The bit error rate (BER) is the amount of bit errors per unit time. The bit error ratio (also BER) is the number of bit errors separated by the total number of transferred bits during a studied time interval. BER is a unit less performance measure, frequently expressed as a percentage.

$$BER = \frac{P}{H \times W} \quad (6)$$

F. (Structural Similarity Index Measurement (SSIM):

The structural similarity (SSIM) [13] index is a method for measuring the similarity between two images. The SSIM index is a full reference metric, in other words, the measuring of image quality based on an initial uncompressed or distortion-free image as reference.

The SSIM metric is calculated on various windows of an image. The measure between two windows 'x' and '*y'* of common size *N*×*N* is:

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)} \quad (7)$$

$\mu_x$the average of x ; μ_y the average of y ; σ_x^2 the variance of x ; σ_y^2 the variance of y;σ_{xy} the covariance of x and y ; $C_1 = ((k_1L))^2$, $C_2 = ((k_2L))^2$ two variables to stabilize the division with weak denominator; L the dynamic range of the pixel-values (typically this is $(2^{\#\, bits\, per\, pixel} - 1)$; $k_1 = 0.01$ and $k_2 = 0.03$ by default.

VII. CONCLUSION

For copyright protection and authentication of medical images nowadays various reversible watermarking techniques is extensively used for improvement in healthcare systems. In this paper we discusses spatial and transform domain reversible technique which is very efficient in providing security to medical information but some are complex to implement and some included noise or blur in the images. So in future work design the system using the best features of both the technique of watermarking due to which we can provide more security to medical images and hide essential information from attacks.

REFERENCES

[1] S.C. Liew, J. M. Zain, "Reversible Medical Image Watermarking for tamper detection and recovery", 3rd IEEE International Conference on Computer Science and Information Technology, Vol 5, **2010**, pp **417-420**.

[2] S.C. Huang, M.S. Lin, "A High-capacity Reversible Data hiding Scheme for medical images", Journal of Medical and Biological Engineering, Vol. 30, (5), **2010**, pp. **289-296**.

[3] C.K. Tan, J.C. Ng, X. Xu, C.L. Poh , Y.L Guan, K. Sheah, "Security Protection of DICOM Medical Images Using Dual-Layer Reversible Watermarking with Tamper Detection Capability", Journal of Digital Imaging, Vol. 24, (3), **2011**, pp. **528-540**.

[4] M Arsalan, S.A.Malik, A.Khan, "Intelligent reversible watermarking in integer wavelet domain for medical images", Journal of Systems and Software, Vol. 85, (4), **2012**, pp. **883–894**.

[5] H.Maity, S.P.Maity, "Joint Robust and Reversible Watermarking for Medical Images", International Conference on Communication, Computing & Security, **2012**, pp. **275-282**.

[6] M.S Hwanga , L.Y. Tsengb ,LC Huang, "A reversible data hiding method by histogram shifting in high quality medical images", Journal of Systems and Software, Vol. 86, (3), **2013**, pp. **716–727**.

[7] Deng, Xiaohong; Chen, Zhigang; Zeng, Feng; Zhang, Yaoping; Mao, Yimin, "Authentication and Recovery of Medical Diagnostic Image Using Dual Reversible Digital Watermarking", Journal of Nanoscience and Nanotechnology, Vol. 13, (3), **2013**, pp. **2099-2107**.

[8] B.Lei, E.L.Tan, S.Chen, D.Ni, T.Wang, H.Lei, "Reversible watermarking scheme for medical image based on differential evolution", Expert Systems with Applications, Vol. 41, (7), **2014**, pp. **3178–3188**.

[9] M. Kumar, H. Agarwal, "Reversible Watermarking Scheme for Medical Image", International Conference on Issues and Challenges n Inteligent Computing Techniques, , **2014**, pp. **844-847**.

[10] A. Phadikar, P. Jana, B.S Phadikar, G.K Maity, "Reversible Watermarking using Channel Coding and Lifting for Cultural Heritage and Medical Image", International Journal of Information and Computer Security, Vol. 8, (1), **2016**, pp. **34-54**.

[11] B.Han, J.Li, M.Huang, "A Novel Medical Image Watermarking in Three-dimensional Fourier Compressed Domain", International Journal Bioautomation, Vol. 19, (3), **2015**, pp. **397-408**.

[12] B.Han, J.Li, "Medical Image Watermarking in Sub-block Three-dimensional Discrete Cosine Transform Domain", International Journal Bioautomation, Vol. 20, (1), **2016**, pp. **69-78**.

[13]Z. Wang, A. C. Bovik, H. R. Sheikh, and E. P. Simoncelli, "Image Quality Assessment: From Error Measurement to Structural Similarity," IEEE Transactions on Image Processing, Vol. 13, **2004**, pp. **1-14.**