Review of Image Watermarking Technique for Medical Images

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Abstract— in this article, we focus on the complementary role of watermarking with respect to medical information security (integrity, authenticity …) and management. We review sample cases where watermarking has been deployed. We conclude that watermarking has found a niche role in healthcare systems, as an instrument for protection of medical information, for secure sharing and handling of medical images. The concern of medical experts on the preservation of documents diagnostic integrity remains paramount. Medical image watermarking is an appropriate method used for enhancing security and authentication of medical data, which is crucial and used for further diagnosis and reference. This paper discusses the available medical image watermarking methods for protecting and authenticating medical data. The paper focuses on algorithms for application of watermarking technique on Region of Non Interest (RONI) of the medical image preserving Region of Interest (ROI).

Keywords— Medical Images, ROI, Security, Attacks.

I.   Introduction

With the rapid development of nanoscience and nanotechnology, its research results have been widely used in all fields of life, especially in biomedical applications. The advanced medical imaging equipments produced by nanotechnology can obtain the internal structure images of human organs with high resolution and accuracy, and they provide the first hand information for medical diagnosis. With the development of modern medicine and the continuous improvement of information technology, more and more researchers have been dedicated to study the internal structure of biological, hoping to find the earlier diagnosis of the disease and establish scientific and reasonable therapy. Therefore, biomedical images have become the most direct and effective researching objects, but these precious medical diagnostic images usually need in the online sharing and transmission due to various requirements, e.g., for the application of telemedicine.

Telemedicine uses telecommunication and information technologies to provide clinical health care at remote areas. It improves access to medical services that are not available in distant rural areas. With the use of telemedicine, patients living in remote communities can avail medical diagnosis from far away specialists, so that the patient need not travel to visit physician for consultation. Many of the medical images contain one or more important areas called ROI and the remaining part is called region of non-interest (RONI). Content of ROI is important for diagnostic decision making.

Digital representation of multimedia content offers various advantages, such as easy and wide distribution of multiple and perfect replications of the original contents. In many circumstances, alternations to content serve legitimate purposes. However, in other cases, the changes may be intentionally malicious or may inadvertently affect the interpretation of the content.

The patient information and medical images need to be organized in an appropriate manner in order to facilitate using and retrieving such data and to avoid mishandling and loss of data [1]. On the other hand, the transmission of such a large amount of data when done separately using ordinary commercial information transmitting channels like Internet, it results in excessive memory utilization, an increase in transmission time and cost and also make that data accessible to unauthorized personnel [2]. In order to overcome the capacity problem and to reduce storage and transmission cost, data hiding techniques are used for concealing patient information with medical images.

Now, various authentication methods of image have recently been presented for verifying the integrity and authenticity of the image's content, if detected the presence of tampering, the tampering localization and approximate recovery is important and necessary. The authentication methods can be organized into two categories: digital signature schemes and digital watermark schemes. The digital signature schemes can be used to detect if an image has been modified owning to the sensitivity of hash value.

Watermarking techniques can be classified into two categories, reversible and irreversible. The reversible watermarking techniques are used to avoid irreversible distortion in image by extracting the original image exactly at the receiver end. Medical image watermarking is one of the most important fields that need such techniques where distortion may cause misdiagnosis [4]. Of course, the reversibly watermarked image is not distortion-free, but that distorted image is used as a carrier for data to be embedded and not for diagnosis. The losslessly recovered image is the final one for diagnosis [5].

Medical image watermarking schemes may be classified into three categories: authentication schemes (including tamper detection and recovery); data-hiding schemes (for hiding electronic patient records); and schemes that combine authentication and data hiding [6]. Authentication schemes are used to identify the source of the image, and tamper detection watermarks are able to locate the regions or pixels of the image where tampering was done. In some cases, tampered areas may be recovered. Data-hiding schemes give more importance in hiding high amount of data in the images and keep the imperceptibility very high. Depending on the purpose of the watermarking (authentication, data hiding, or both), a proper watermarking technique is chosen accordingly.

II. Literature Review

Jeffery H. K. Wu et al[1]: proposed two methods to tamper detection and recovery for a medical image. A 1024 1024 x-ray mammogram was chosen to test the ability of tamper detection and recovery. At first, a medical image is divided into several blocks. For each block, an adaptive robust digital watermarking method combined with the module operation is used to hide both the authentication message and the recovery information. In this study, an adaptive robust digital water marking method combined with the operation of modulo 256 was chosen to achieve information hiding and image authentication. With the proposal method, any random changes on the stego image will be detected in high probability.

Keshi Chen et al [2]: The near-lossless, i.e., lossy but high-fidelity, compression of medical images using the entropy-coded DPCM method is investigated. A source model with multiple contexts and arithmetic coding are used to enhance the compression performance of the method. In implementing the method, two different quantizes each with a large number of quantization levels are considered. Experiments involving several MR (Magnetic Resonance) and US (Ultrasound) images show that the entropy-coded DPCM method can provide compression in the range from 4 to 10 with a peak SNR of about 50 dB for 8-bit medical images. The use of multiple contexts is found to improve the compression performance by about 25% to 30% for MR images and 30% to 35% for US images. A comparison with the PEG standard reveals that the entropy-coded DPCM method can provide about 7 to 8 dB higher SNR for the same compression performance.

Tjokorda Agung B.W et al [3]: By embedding fragile authentication watermark, the watermarking system can detect and localize the tampered area of medical images. Moreover, by embedding the feature extraction in the form of average intensities of the image, an original image can be recovered from the tampered image. This paper will study and test a watermarking scheme using LSB Modification to perform tamper detection and recovery in the ROI. To make this watermarking scheme reversible, RLE is used to embed the original LSBs in the RONI to get higher embedding capacity. The experimental results show that this watermarking system can detect and localize tamper with up to 100% accuracy and perform image recovery up to 100% recovery rate until 20% of tempered area in ROI.

Nisar Ahmed Memon and Syed Asif Mehmood Gilani[4]: proposed multiple watermarking method for authentication of medical images. CT scan images have been chosen for testing the algorithm. In order to achieve high imperceptibility, data embedding technique based on adaptive data hiding method in wavelet domain has been implemented. Experimental results show that the proposed scheme outperforms the prior works in terms of PSNR and MSE. Digital medical images are very easy to be modified for illegal purposes. For example malignant nodules on lung parenchyma in chest CT scan images is an important diagnostic clue, and it can be wiped of intentionally for insurance purposes or added intentionally into chest CT Scan images.

Osamah M. Al-Qershi, Bee Ee Khoo[5]: presents a lossless watermarking technique for Ultrasound (US) images. The proposed technique adopts a high-capacity reversible data hiding scheme based on difference expansion (DE). It can be used to hide patient's data hiding and protecting the region of interest (ROI) with tamper detection and recovery capability. The experimental results show that the original image can be exactly extracted from the watermarked one in case of no tampering. In case of tampered ROI, tampered area can be localized and recovered losslessly.

Sang-Kwang Lee et al [6]: proposed a new reversible image authentication technique based on watermarking where if the image is authentic, the distortion due to embedding can be completely removed from the watermarked image after the hidden data has been extracted. This technique utilizes histogram characteristics of the difference image and modifies pixel values slightly to embed more data than other lossless data hiding algorithm. We show that the lower bound of the PSNR (peak-signal-to-noise-ratio) values of watermarked images are 51.14 dB. Moreover, the proposed scheme is quite simple and the execution time is rather short. Experimental results demonstrate that the proposed scheme can detect any modifications of the watermarked image.

Jun Tian [7]: Reversible data embedding has drawn lots of interest recently. Being reversible, the original digital content can be completely restored. In this paper, they present a novel reversible data embedding method for digital images. We explore the redundancy in digital images to achieve very high embedding capacity, and keep the distortion low.

Rayachoti Eswaraiah, Edara Sreenivasa Reddy [8]: authors propose a novel medical image watermarking method based on integer wavelet transform (IWT). This proposal verifies the integrity of ROI, precisely identifies tampered blocks inside ROI, provides robustness to the data embedded inside region of non-interest (RONI) and recovers original ROI. In the proposed method, the medical image is segmented into ROI and RONI regions. Hash value of ROI, recovery data of ROI and data of patient are embedded into RONI using IWT. Experimental results show that the proposed method provides robustness to the watermark data embedded inside RONI and accurately detects and localizes tampered areas inside ROI and recovers the original ROI.

Kuo-Hwa Chiang et al[9]: on the basis of lossless data-embedding techniques, two detection and restoration systems are proposed to cope with forgery of medical images in this paper. One of them has the ability to recover the whole blocks of the image and the other enables to recover only a particular region where a physician will be interested in, with a better visual quality. Moreover, once an image is announced authentic, the original image can be derived from the stego-image losslessly. The experimental results show that the restored version of a tampered image in the first method is extremely close to the original one. As to the second method, the region of interest selected by a physician can be recovered without any loss, when it is tampered.

Sudeb Das and Malay Kumar Kundu [10]: proposed a blind, fragile and Region of Interest (ROI) lossless medical image watermarking (MIW) technique, providing an all-in-one solution tool to various. The proposed scheme combines lossless data

compression and encryption technique to embed electronic health record (EHR)/DICOM metadata, image hash, indexing keyword, doctor identification code and tamper localization information in the medical images. Moreover, given its relative simplicity, the proposed scheme can be applied to the medical images to serve in many medical applications concerned with privacy protection, safety, and management.

Kyung-Su Kim etal[11]: This paper presents a region-based tampering detection and restoring scheme that exploits both lossless (reversible) data hiding and image homogeneity analysis for image authentication and integrity verification. The proposed scheme enables the detection of a tampered region and then recovers it by using the embedded information selected as the recovery feature. Through experiments on 8-bit, 12-bit, and 16-bit images, we demonstrate the effectiveness of tampering localization of the proposed method and show that restoration is achieved with high visual quality.

Xiao Wei Li, Seok Tae Kim [12]: The paper presents a 3D watermark based medical image watermarking scheme. In this paper, a 3D watermark object is first decomposed into 2D elemental image array (EIA) by a lens let array, and then the 2D elemental image array data is embedded into the host image. The watermark extraction process is an inverse process of embedding. Furthermore, using CAT with various rule number parameters, it is possible to get many channels for embedding. So our method can recover the weak point having only one transform plane in traditional watermarking methods. The effectiveness of the proposed watermarking scheme is demonstrated with the aid of experimental results.

Xiaohong Deng et al[13]: proposes 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. Firstly, the quad-tree decomposition is used to divide the original image into blocks with high homogeneity, and then we computer pixels' linear interpolation as each block's recovery feature. Secondly, these recovery features as the first layer watermarking information is embedded by using simple invertible integer transformation. Experimental results show that, compared with previous similar existing scheme, the proposed method not only achieves.

Rayachoti Eswaraiah and Edara Sreenivasa Reddy [14]: authors propose a novel medical image watermarking method based on integer wavelet transform (IWT). This proposal verifies the integrity of ROI, precisely identifies tampered blocks inside ROI, provides robustness to the data embedded inside region of non-interest (RONI) and recovers original ROI. In the proposed method, the medical image is segmented into ROI and RONI regions. Hash value of ROI, recovery data of ROI and data of patient are embedded into RONI using IWT. Experimental results show that the proposed method provides robustness to the watermark data embedded inside RONI and accurately detects and localizes tampered areas inside ROI and recovers the original ROI.

III.   Conclusions

There exists various medical image watermarking algorithms and different existing segmentation algorithms to segment ROI. The segmentation algorithms vary for the types of medical images such as MRI, CT, US, etc. The current study work can further be extended to develop a GUI tool based approach for separating the ROI. Additionally, a new technique of separating ROI form the original image that will be applicable for all type of medical images can be evolved. Separated ROI can be stored with xmin, xmax, ymin, and ymax value so that at the end of embedding process before transmitting watermarked image, the segmented ROI can be attached with watermarked image. Any medical image watermarking approach will be suitable, if we segment the ROI from medical image with the four values, then embedding of watermark can be done on whole medical image. Therefore, space for watermark embedding will be more in such case.

References

[1] Wu, Jeffery HK, et al. "Tamper detection and recovery for medical images using near-lossless information hiding technique." *Journal of Digital Imaging* 21.1 (2008): 59-76.

[2] Chen, Keshi, and Tenkasi V. Ramabadran. "Near-lossless compression of medical images through entropy-coded DPCM." *IEEE Transactions on Medical Imaging* 13.3 (1994): 538-548

[3] Permana, Febri Puguh. "Medical image watermarking with tamper detection and recovery using reversible watermarking with LSB modification and run length encoding (RLE) compression."*Communication, Networks and Satellite (ComNetSat), 2012 IEEE International Conference on*. IEEE, 2012.

[4] Memon, Nisar Ahmed, and Syed Asif Mehmood Gilani. "Adaptive data hiding scheme for medical images using integer wavelet transform."*Emerging Technologies, 2009. ICET 2009. International Conference on*. IEEE, 2009.

[5] Al-Qershi, Osamah M., and Bee Ee Khoo. "ROI-based tamper detection and recovery for medical images using reversible watermarking technique." *Information Theory and Information Security (ICITIS), 2010 IEEE International Conference on*. IEEE, 2010.
[6] Lee, Sang-Kwang, Young-Ho Suh, and Yo-Sung Ho. "Reversiblee Image Authentication Based on Watermarking." *2006 IEEE International Conference on Multimedia and Expo*. IEEE, 2006.

[7] Tian, Jun. "Reversible data embedding using a difference expansion."*IEEE Trans. Circuits Syst. Video Techn.* 13.8 (2003): 890-896.

[8] Eswaraiah, Rayachoti, and Edara Sreenivasa Reddy. "Robust medical image watermarking technique for accurate detection of tampers inside region of interest and recovering original region of interest." *IET Image Processing* 9.8 (2015): 615-625.

[9] Chiang, Kuo-Hwa, et al. "Tamper detection and restoring system for medical images using wavelet-based reversible data embedding."*Journal of Digital Imaging* 21.1 (2008): 77-90.

[10] Das, Sudeb, and Malay Kumar Kundu. "Effective management of medical information through ROI-lossless fragile image watermarking technique."*Computer methods and programs in biomedicine* 111.3 (2013): 662-675.

[11] Kim, Kyung-Su, et al. "Region-based tampering detection and recovery using homogeneity analysis in quality-sensitive imaging." *Computer Vision and Image Understanding* 115.9 (2011): 1308-1323.

[12] Li, Xiao Wei, and Seok Tae Kim. "Optical 3D watermark based digital image watermarking for telemedicine." *Optics and Lasers in Engineering*51.12 (2013): 1310-1320.

[13] Deng, Xiaohong, et al. "Authentication and recovery of medical diagnostic image using dual reversible digital watermarking." *Journal of nanoscience and nanotechnology* 13.3 (2013): 2099-2107.

[14] Deng, Xiaohong, et al. "Authentication and recovery of medical diagnostic image using dual reversible digital watermarking." *Journal of nanoscience and nanotechnology* 13.3 (2013): 2099-2107.