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Survey on Digital Watermarking on Medical Images

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Abstract

The rapid growth in information and communication technologies has advances the medical data management systems immensely. In this regard, many different techniques and also the advanced equipment like Magnetic Resonance Imaging (MRI) Scanner, Computer Tomography (CT) scanner, Positron Emission of Tomography (PET), mammography, ultrasound, radiography etc. are used. Nowadays there is a rise of various diseases, for which several diagnoses are insufficient; therefore to achieve a correct diagnostic, there is need to exchange the data over Internet, but the main problem is while exchanging the data over Internet, we need to maintain their authenticity, integrity and confidentiality. Therefore, we need a system for effective storage, transmission, controlled manipulation and access of medical data keeping its authenticity, integrity and confidentiality. In this article, we discuss various water marking techniques used for effective storage, transmission, controlled manipulation and access of medical data keeping its authenticity, integrity and confidentiality.

Keywords

DWT, DCT, LSB, SVD

1. Introduction

Digital water marking works by concealing information within digital data, such that it cannot be detected without special software with the purpose of making sure the concealed data is present in all copies of data that are made whether legally or otherwise of attempts to damage/remove it.

Internet is used to transfer or receive medical data by healthcare professional. Due to advancement in information and communication technologies, a new context of easier access, manipulation, and distribution of this digital data have been established. The medical images can be readily shared via computer networks and easily used, processed, and transmitted by using great spread network.

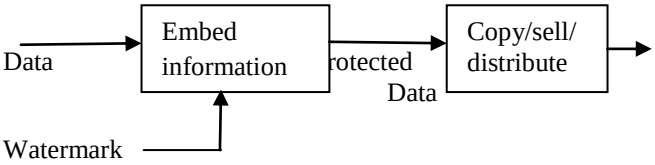

Figure 1: Block diagram of DWM

Ideal properties of a digital watermark have been stated in many articles. These properties include:

1) A digital watermark should be perceptually invisible to prevent obstruction of the original image.
2) A digital watermark should be statistically invisible so it cannot be detected or erased.
3) Watermark extraction should be fairly simple. Otherwise, the detection process requires too much time or computation.
4) Watermark detection should be accurate. False positives, the detection of a non-marked image, and false negatives, the non-detection of a marked image, should be few.
5) Numerous watermarks can be produced. Otherwise, only a limited number of images may be marked.
6) Watermarks should be robust to filtering, additive noise, compression, and other forms of image manipulation.
7) The watermark should be able to determine the true owner of the image.

Medical informatics/Record keeping is gaining paramount importance in health care industry in recent years. Digital water marking can be used in medical application to increase medical image security (Counterfeiting, forgery, fraud, pirating, protecting information and content), confidentiality and integrity.

Medical image watermarking is a one of the subcategory of image watermarking in which the images have special requirements. Particularly, watermarked medical images should not differ from their original counterparts, because the clinical reading of the images (e.g. diagnosis) must not be affected. There are two regions in which the medical image can be water marked: a) ROI & b) RONI.
In reversible water marking scheme, a water mark is inserted into the original image in a reversible

manner in which when the water mark is extracted the original image can be recovered properly.

Many researchers applied water marking techniques for medical data. Imen [1] presented a reversible water marking for providing authentication, tamper proofing and to recover the original image from the suspected image. He used spatial domain method to divide the images into blocks and computes message authentication codes and inserted into the LSB parts of expanded differences of the selected pixels in each block. Jasni [2] applied water marking techniques to verify the integrity and authentication of DICOM images. In this SHA-256 of the image is embedded in LSB of the RONI and also showed that if the image is not altered, the water mark will be extracted and the original image will be recovered.

Sudeb [3] describes about a non-blind imperceptible and highly robust hybrid Medical Image Watermarking (MIW) technique for a range of medical data management issues. He used CLT followed by DCT to achieve higher robustness and imperceptibility. The drawback of this work is degradation of image and extraction accuracy.

Mohamed Ali Hajjaji [4] proposed an approach for Watermarking image based on the techniques of Code Division Multiple Access (CDMA), Discrete Wavelet transform (DWT) and Error Correcting Code (ECC) in order to contribute to security sharing and transmission of medical images. This approach improves the quantity of data integration with the conservation of the image visual quality and permits the user, to correct the any alterations if it exists. In this work, the hash function MD5 is used to improve the message integrity and the CDMA to increase the number of bits to insert & BCH code is used as an Error Correcting Code in order to correct the eventual errors that may occur due to various attacks. The disadvantage of this approach is that, in the case of Gaussian noise attack the received message undergoes different alterations and also the major inconvenient of this method is the use of different layers, key, and this becomes binding when dealing with a large number of images.

Mona M. Soliman [5] proposed a water marking technique for the medical images in which she applied DWT to the host image followed by DCT. Then a set of final quantization steps are applied to both the characteristics of the DCT domain human visual masking and particle swarm optimization of each block to ensure a high perceptual quality of watermarked image and a low bit error rate of the detected watermark. Finally, watermark is embedded into the singular values vector of each block by adaptive and optimized quantization steps. However this method lags in the image quality as the quantization steps are more. In other words, the robustness and the imperceptibility of the watermark are contradictory to each other since water mark directly affects the image.

Muhammad Tahir Naseem [6] proposes a fragile reversible watermark using cyclic redundancy check (CRC) which is embedded chaotically to some of the pixels and the rest of the pixels are changed into residues. And also showed that by adding a chaotic watermark, the watermarked pixel becomes twelve bits and the residues also became twelve bits, after applying CRC, which makes the medical image secure by confusing the attacker about the location of watermark. The complexity of proposed system is very low to make it possible for real-time medical imaging however the main disadvantage of the proposed system is ,the encryption tools, the execution time is very low which discomforts such kind of schemes for medical use.

Sonika C. Rathi [7] proposed a system in which an algorithm proposed by Giakoumaki to separate ROI from the host medical image that will be applicable for all types of medical images. Separated ROI can be stored so that at the end of embedding process before transmitting watermarked image, the segmented ROI can be attached with watermarked image. So the ROI region which is considered as a critical data and used as a reference by the physician for the treatment will be safe. The drawback of the proposed system uses DWT approach for embedding the watermark, which make the system less robust and secure.

Baisa L. Gunjal [8] applies a watermarking technique for Medical Images for Secured Communication in Telemedicine in which the Region of Interest (ROI) and Non Region of Interest (RONI) of medical image are separated. Only RONI is used for watermark embedding. The DWT technique is used which results in exact recovery of watermark with standard medical database images of size 512x512, and gives a ‘correlation factor’ equals to 1. Compression standard JPEG2000 has replaced Discrete Cosine Transform by Discrete Wavelet Transform. The drawback of this work is non-blind.

In the work [9],In this paper, they have adapted the image lossless watermarking modulation proposed by De Vleeschouwer et al., which is based on the circular interpretation of bijective modulations, in order to the protect the medical relational databases. In this work, the numerical attributes of the database is modulated. They have shown that this scheme is suited for any of the following: copyright protection, integrity control or traitor tracing, robust to most common database attacks, such as the addition and removal of tuples and also the modification of attributes' values.

In the work [11], to maintain the authenticity of ownership and to prevent the damage to the images when the image is manipulated; they have implemented Reed-Solomon code for robust watermark in wavelet domain and SHA-256 for fragile watermark in Hash Block Chaining. The multiple watermarks are implemented simultaneously on an image so that the integrity control and authenticity of the image detection can be applied at the same time.

In the paper [12], a robust approach for transmission of medical images with concealed patient information as watermark is implemented. In this work, they have employed spatial domain digital watermarking technique where the patient information is embedded as watermark into the lower order bits of the medical image pixels. The watermark, which is the text data, is encrypted in order to prevent unauthorized access of data. In order to achieve the robustness of the embedded information, the encrypted watermark is coded by employing Reed Solomon (RS) codes and low density parity check codes (LDPC).They have evaluated extracted watermark accuracy three different regions of the image with no noise and also the bursty wireless channel is simulated by adding impulse noise to the embedded image. Furthermore, turbo channel coding has been proposed to correct the transmission errors over impulsive noisy wireless channels.

In the scheme [13] they have employed fragile authentication watermarking system to detect and localize the tampered area of medical images. In this paper the watermarking scheme is been tested using LSB Modification to perform tamper detection and recovery in the ROI. In order to make this watermarking scheme reversible, RLE is employed to embed the original LSBs in the RONI to get higher embedding capacity. In this work it is been shown that the proposed 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.

In the paper [10], a medical image integrity verification system is presented to detect and approximate local malevolent image alterations as well as identifying the nature of a global processing an image may have undergone. In this paper, it is shown that how the geometric moments can be used to approximate any local modification by its nearest generalized 2-D Gaussian. And then it is demonstrated to show how the ratios between original and recomputed geometric moments is used as image features in a classifier-based strategy in order to determine the nature of a global image processing. In this work it is proved that with a pixel block signature of about 200 bit long, it is possible to detect, to roughly localize, and to get an idea about the image tamper.

Even though many research is been done for the medical images, data hiding has not been explored in healthcare. There are numerous applications waiting to be discovered in medical knowledge and information use in the field like teaching, research and health. However, one important data hiding limitation is due to the size of the message that can be embedded in a medical image and the quality of the medical image, which depends on the watermarking technique employed.

2. Digital Watermarking techniques

The Internet is essential in hospital and medical imaging fields these days. Many medical images are accessed and processed on the web, as well as in picture archiving and communication system. Therefore, any possible accidents can happen by the illegal modification of medical images. To prevent this, it is necessary to develop efficient watermarking techniques for medical image processing and communication system which can prevent an important data contained in original images from being corrupted.

Watermarking can be done by various methods like: least significant bit (LSB), singular value decomposition (SVD), discrete cosine transforms (DCT) and Discrete wavelet transform (DWT) techniques.

***Least significant bit (LSB)*:** In this scheme watermark is embedded in LSB of an image. The

advantage of this method is simplicity whereas the main disadvantage with this method is it gives a low robustness.

***Singular value decomposition (SVD)*:** This is one of the most frequently used tools of linear algebra with several applications in image compression, watermarking and other areas of signal processing. In watermarking most of the SVD techniques are used to modify the singular values of host image by the singular values of watermark.

***Discrete wavelet Transform (DWT)*:** Discrete Wavelet Transform gives good spatial localization, frequency spread, and multi resolution characteristics independently; In order to achieve the image resolution ,the discrete wavelet transform divides the image into different bands with different frequency.
DWT divides an image into various components like: lower resolution approximation image (LL) as well as horizontal (HL), vertical (LH) and diagonal (HH) components. Then the whole process can be repeated in order to compute multiple scale wavelet de-compositions.

***Discrete Cosine Transform*:** The DCT is a very widely used transform function in signal processing. The function of DCT is to transform a signal from spatial domain to frequency domain. It has been used in JPEG standard for image compression as it gives better performance compared to other techniques.
DCT method is applied to many applications such as data compression, pattern recognition, and image processing, and so on. The DCT transforms image into non-overlapped $m \times m$ block. The left-top coefficient of the transformed image is the DC value whereas the others are an AC component which means the energy distribution from high frequency to low frequency as well as from low frequency to high frequency. As the human eyes are more sensitive to noise in lower-frequency band than higher frequency, the energy of natural image is usually concentrated in the lower frequency range. The watermark hidden in the higher frequency band might be discarded after a lossy image compression. Hence, the watermark is always embedded in the lower-band range of the host image.
In the design of the watermark, an explicit model of HVS (human Visual System) is employed in order to exploit spatial and temporal masking.

DCT and DWT can be used along with efficient algorithms to improve the robustness, integrity and confidentiality of the medical images.

3. Comparison of Related Works

The, several new technologies are developed to preserve the authentication of information. Digital water marking is one of them. It is a technique that allows us to add hidden copyright notices, verification messages or any other useful information to the original signal. The hidden message can be a group of bits that describe something about the signal or about the genuine author of the signal. The description can be about the name, place or something related to this. Much of the research work has been done in the field of digital watermarking in the recent period of time, a brief comparison about various digital water marking techniques for different media types is given in the below.

4. Conclusion and future enhancement

This article provides the overall view of digital water marking and its features and its applications and work done in various fields. The survey has been done for the various watermarking techniques used for watermarking the medical image.

Although there are several work is done in order to authenticate, integrity and confidentiality of the medical images, there remains a lot to be done in this field. The digital watermarking can also be implemented with VLSI techniques using software and hardware with more efficient algorithms. We propose to develop and have an interactive approach to learn about the digital watermarking... Due to the growing usage of multimedia content on the Internet, serious issues have emerged like Counterfeiting, forgery, fraud, and pirating of this content. Protecting information and content has not received the attention that it deserves. Digital watermarking seems to be the only potential encryption technology to provide protection even after data is decrypted.

Table-1: Comparison of Related Works

Imen Fourati Kallel	Tamper localization Extraction accuracy To minimize Overflow and Underflow problem	Bounded by block size Medium difference of the pair of grey scale values small and grey values are restricted to[0,255]	Blind
Jasni	Embedding method PSNR	Asymmetric key method 32db	Non blind NROI
P Vishwanathan	Embedding Capacity Watermark intensity Embedding capacity Pseudo random bit sequence generation	Low since pixel value is limited to 255 bits. Difficult to adjust Low before embedding the information for modifying the intensity values	Non blind NROI
Mustafa Ulutas	Number of coefficients to code secret pixel values. Run time	Depends on bit depth of the medical images. High for larger value of k.	
Sunita v Dhavale	PSNR	Medium , decreases as energy threshold factor w increases.	Blind
Malay Kumar Kundu	PSNR Image depth Embedded data	Moderate Limited to 16 bit Only EPR	Blind
Sudeb Das and Malay Kumar Kundu	Encrypted EPR Extraction accuracy Image degradation	1152bits Less more	Non blind
Sudeb Das and Malay Kumar Kundu		Undergoes different alterations due to guassian attack. Cannot handle larger number of images as it uses several layers and keys	Non blind
Mohamed Ali HAJJAJI, Abdellatif MTIBAA	Extract data efficiency Good result for "copy/paste" attack, impultionnel noise attack and the JPEG 2000 compression	Low,it cannot extract all data due to guassian attack. When rate of compression is limited to 50%.	Blind
Sonika C. Rathi	Accuracy Security	Less Not sustainable to guassian attack. Good but consumes more time for larger images as it uses Arnold transform	Non blind
Koushik Pal		Proposed algorithm withstand only 40% pepper and salt noise and 5% JPEG Compression leads to fuzziness.	Blind
Siau-Chuin Liew	Tamper detection and recovery	Good, testing is required to know the perceptibility of the watermarked image.	ROI,RONI Blind
Mona M. Soliman	Robustness	Increased, but as quantization step is increased, the quality of the host image decreases.	RONI Blind

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References

[1] Digital watermarking of medical image using ROI information- Enterprise networking and Computing in Healthcare Industry, 2005,ISBN:0-7803-8940-9 June 2005.

[2] Improved Tian's Method for Medical Image Reversible Watermarking-Imen Fourati Kallel1,2, Mohamed Salim Bouhlel1 and Jean-Christophe Lapayre2 *1RU: Sciences and Technologies of Image and Telecommunications (SETIT),ISBS – Tunisia 2 Laboratory of Franche Comte (LIFC) (FRE CNRS 2661) Besançon – France*-GVIP Journal, Volume 7, Issue 2, August, 2007.

[3] Blind Robust Image Adaptive Watermarking for Medical Images with Multilevel Security-Sunita V. Dhavale- International Journal of Computer Science and Application Issue 2010- ISSN 0974-0767.

[4] Hybrid Contour let-DCT Based Robust Image Watermarking Technique Applied to Medical Data Management- Sudeb Das and Malay Kumar Kundu- S.O. Kuznetsov et al. (Eds.): PReMI 2011, LNCS 6744, pp. 286–292, 2011.c_Springer-Verlag Berlin Heidelberg 2011.

[5] A Watermarking of Medical Image: Method Based "LSB"- Mohamed Ali HAJJAJI, Abdellatif MTIBAA, El-bey BOURENNANE- VOL. 2, NO. 12, December 2011 ISSN 2079-8407- Journal of Emerging Trends in Computing and Information Sciences.

[6] Medical images authentication through watermarking preserving roi- Sonika C. Rathi and Vandana S. Inamdar- Health Informatics - An International Journal (HIIJ) Vol.1, No.1, August 2012.

[7] Invertible and Fragile Watermarking for Medical Images Using Residue Number System and Chaos- Muhammad Tahir Naseem- School of Engineering & Applied Sciences (SEAS), ISRA University, Islamabad Campus, Pakistan- ISSN 2090-4304 Journal of Basic and Applied Scientific Research*J. Basic. Appl. Sci. Res.*, 2(10)10643-10651, 2012.

[8] ROI Based Embedded Watermarking of Medical Images for Secured Communication in Telemedicine- Baisa L. Gunjal, Suresh N. Mali- International Journal of Computer and Communication Engineering 6 2012.

[9] Distortion Free Fragile Watermarking Technique For Medical Images-SHAIK. BASHEERA- International Journal of Computer Science Engineering and Information Technology Research (IJCSEITR) ISSN 2249-6831 Vol. 3, Issue 2, June 2013.

[10] A Watermarking-Based Medical Image Integrity Control System and an Image Moment Signature for Tampering Characterization- Biomedical and Health Informatics, IEEE Journal- ISSN : 2168-2194 , Nov. 2013.

[11] Multiple watermarking on digital medical images for tamper detection and integrity control- Uncertainty Reasoning and Knowledge Engineering (URKE), 2012 2nd International Conference on- ISBN: 978-1-4673-1459-6- Aug. 2012.

[12] Robust Transmission of Watermarked Medical Images over Wireless Channels- Global Humanitarian Technology Conference (GHTC), 2012 IEEE- ISBN: 978-1-4673-3016-9 - Oct. 2012.

[13] 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)- ISBN: 978-1-4673-0888-5 July 2012.

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