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Securing Medical Images Using Digital Watermarking

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Abstract— Modern healthcare systems are based on managing diagnostic information of patients in a digital way. To guarantee the security, authenticity and management of medical images and information through storage and distribution, the watermarking techniques are used. Medical image watermarking is an appropriate method used for enhancing security and authentication of medical data. This paper discusses the available medical image watermarking methods for protecting and authenticating medical data. As a lossless technique, the original image can be perfectly recovered by performing the reverse process of the watermark embedding if the watermarked image is intact.

Keywords—Lossless watermarking, DICOM, reversible, ROI & RONI, Authentication, Encryption, medical confidentiality

I. INTRODUCTION

Digital watermarking can be used as an important tool for the security and copyright protection of digital multimedia content. For protecting medical images, digital watermarking is an emerging technique, which includes the embedding and extraction process. In embedding process some secret information is embed in to medical images. Extraction process deals with the extraction of secret message, which embedded in the medical image. If failure occurs in extraction process the physician would come to know that there has been some kind of tampering with that image, and he would take precaution of not making diagnosis based on that image. However, if the extraction process extracts the correct watermark, which generally consumes a few seconds, physician can continue with diagnosis.

The watermarking system must be imperceptible, statistically undetectable, resistant to lossy data and unambiguous. A good system must have good perceptually significant component against lossy and should resemble the image to protect any operation that is intentionally performed to damage the watermark which in turn causes damage in image. The frequency domain of the image is viewed as a communication channel and watermarking as a signal that is transmitted through it.

The most important properties of any digital watermarking techniques are robustness, security, imperceptibility, complexity and verification. Robustness is defined as if the watermark can be detected after media operations such as filtering, lossy compression, color correction, or geometric modifications.

Security means that the embedded watermark can't be removed beyond reliable detection by targeted attacks. Imperceptibility means that the watermark is not seen by the human visual system. Complexity is described as the effort and time required for watermark embedding and retrieval. Lastly, verification is a procedure whereby is used as a private key or public key function. Each of these properties must be taken into consideration when applying a certain digital watermarking technique.

Medical image security is an important issue when digital images and their pertinent patient information are transmitted across public networks. Most of the hospitals physicians diagnose their patients by relying on the provided electronic and digital data (such as Ultrasonic, Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and X-ray images). This results in generation of large number of electro digital data (i.e. medical images) continuously at various health care centers and hospitals around the world. One physician can transfer the medical image to another physician for second opinion. The medical images are stored in patient historical database for future diagnosis. So there is a need to provide a strict security in medical images to ensure only occurrence of legitimate changes.

In this paper, a study on the different techniques used for securing medical images using digital watermarking are discussed. These techniques are mainly used to verify the integrity and authenticity of medical images.

II. TECHNIQUES USED FOR MEDICAL IMAGE WATERMARKING

Many watermarking schemes were proposed for medical images. Those techniques can be spatial domain techniques, frequency domain techniques, or a combination of the two domains. A security technique based on watermarking and encryption for DICOM is proposed by Mohamed M. Abd-Eldayem et al. [1] where the original image can be recovered completely. In this paper, a R-S vector is created which is then compressed. A hash value of the image is determined using MD5 hash function. This MD5 hash value along with the compressed R–S vector of the original image are concatenated, and then they are encrypted using AES encryption technique. This watermark is then embedded into the original image. During the extraction process, the exact reverse of the embedding process is performed and the original image is retrieved. Then the hash value of the extracted original image is calculated and is compared with the previous hash value. If they are equal, the image is authenticated, and it has right integrity, else the image is discarded because its integrity is broken. Extended Huffman algorithm is used to decompress the decrypted R–S Vector. The performance of the proposed technique is measured using the performance parameters: Signal to Noise Ratio (SNR), Mean Square Error (MSE), and Bit Error Rate (BER). The experiment results shows that the proposed technique is totally revertible and the original images can be retrieved at the receiver side without any distortion.

Another lossless watermarking scheme for DICOM images is proposed by Osamah M. et al. [2]. This paper is based on a fragile scheme combining two reversible techniques. These techniques are based on difference expansion and protecting the region of interest (ROI) with tamper detection and recovery capability. Here two watermarks are produced where the 1st watermark, which consists of patient's data and the hash message of ROI is embedded into ROI. As a result, an embedding map is produced which will be used to extract the 1st watermark. The map is then combined with recovery information to become a part of the 2nd watermark. This watermark is embedded into RONI. The experiment result shows that the watermarked images have good visual quality in terms of PSNR, with high embedding capacity.

A joint Encryption/Watermarking system is proposed by D. Bouslimi et al. [3] for the purpose of protecting medical images. Here, a substitutive watermarking algorithm, the quantization index modulation (QIM), is combined with an encryption algorithm. This paper mainly aims at the verification of the reliability of an image within both the spatial domain and encrypted domain. The proposed scheme consists of two stages: protection and verification. During the protection stage, the watermarking and encryption of an image is conducted. Two messages are inserted where each message has a watermarking key for their respective domain. In the spatial domain, a secure hash function is used to ensure integrity. In the encrypted domain, integrity is ensured by verifying the

presence of a secret pseudo random sequence of bits. The experimental results show that the image distortion is very low.

Nyeem and Hussain [4] has proposed an efficient border pixel based watermark embedding scheme for medical images. It is an irreversible and spatial domain embedding scheme. They mainly aimed at watermark embedding to achieve an image content-independent capacity with a low computational complexity. Here, the border pixels of a medical image is taken as RONI. A set of suitable LSB planes of border pixels are chosen for watermark embedding. The other pixels are remained untouched. The border pixels are selected because ROI/RONI segmentation problem can be solved, the legal and ethical issues can be minimized and the continuous protection of medical images can be facilitated.

Another scheme for authentication of medical images by preserving ROI is proposed by Sonika C. Rathi et al. [5]. The proposed method does watermarking on Region of Non Interest (RONI) so that the medical images can be transferred securely without affecting the Region of Interest (ROI). The segmentation of ROI is done by GUI based approach. This scheme consists of two steps:- extracting ROI from medical images and applying watermarking on RONI. The ROI segmentation is performed by partitioning the image into separate regions by grouping together neighborhood pixels on the basis of predefined similarity criterion. The GUI based system returns the Xmin, Xmax, Ymin, Ymax pixel values of selected ROI region and image of selected ROI. This resulted ROI image can be saved, so that it can be combined with the resultant watermarked image In this way, the entire medical image is divided into white and gray subregions. After segmentation, a fragile watermarking system is used and the watermark is embedded into the RONI. The separated watermark is then combined with the produced watermarked image and the output is sent to the receiver. Similarly ROI is separated during the extraction phase and then the exact reverse of the embedding process is performed. Since the ROI region consists of critical data, it can be used as a reference by the physician for the safe treatment.

A Joint Robust and Reversible Watermarking for Medical Images proposed by Hirak Kumar et al. [6] also partitions the whole image into two regions called region of interest (ROI) and region of non-interest (RONI). In order to generate a watermarked image, a reversible watermark is embedded into ROI and a robust watermark is embedded into RONI. Initially, the proposed system divides the original image into ROI and RONI image of the same size with its original one. This can be done on the basis of some morphological operations or by specifying polygon region of interest in MATLAB. In morphological image processing operation, an image get processed on the basis of its shape i.e. the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbours.

Thus a binary mask is created in which the white portion of an image contained ROI and the black portion contained RONI. The reversible watermarking is done using RCM approach which results in low mathematical complexity and the robust watermarking is done using Spread Spectrum approach for its imperceptibility and robustness property.

J. M. Zain and L.P Baldwin et al. [7] proposed a watermarking scheme that can recover the original image from the watermarked one. The main purpose of the proposed scheme is to verify the integrity and authenticity of DICOM images. Here SHA-256 hash function is used. At the sender site, the ROI is defined and SHA-256 hash value for the whole image is computed. This computed hash value is then embedded into the RONI in their LSB. At the receiver site, the watermark is extracted by visiting the back to the watermarking area and read the LSB value. Then the flipping function is applied to the LSB. Again the SHA-256 hash value of the extracted image is computed. SHA-256 of the recovered image will be compared with the extracted watermark for authentication. If they are the same, then the image is authentic and that it has not been tampered.

A Block Based Medical Image Watermarking Technique for Tamper Detection and Recovery by Eswaraiah Rayachoti et al. [8] proposed a fragile block based medical image watermarking technique for embedding data of patient into medical image. In this method, the image is first divided into three regions: ROI (Region of Interest), RONI (Region of Non Interest) and border pixels. After selecting ROI, the hash value of the ROI is calculated using MD5. Using this hash value along with LSBs of pixels inside ROI and EPR of patient, a watermark is generated which is then compressed using Run Length Encoding (RLE). To provide security, the compressed watermark is encrypted using a secret key. The resultant watermark is embedded into LSBs of ROI pixels. Then, the RONI is divided into non-overlapping blocks and is mapped into corresponding ROI block. Here, recovery information of ROI is embedded inside RONI and information of ROI is embedded inside border pixels. The experimental results shows that the proposed method produces high quality watermarked medical images.

Neha Solanki and Sanjay K. Malik [9] propose another medical image watermarking method with zero distortion and enhanced security. Here also the image is first divided into two parts: Region of Interest which contains the informational part of image and Region of Non Interest which contains the non-informational part. For the separation of ROI and RONI, the loaded medical image is subtracted from its negative image. Then to find high intensity areas thresholding is done. Then the watermark is encrypted using RSA which uses two types of keys: one public key for encryption and a private key for decryption. The watermarking technique used here is DWT (Discrete Wavelet Transform) which includes two operations: one horizontally and other vertically. Then the watermark is embedded using the algorithm "CImage, himage "and is extracted using the algorithm "EImage, himage". The results show that the proposed scheme has high image quality, security and imperceptibility.

A secure sharing of medical information in watermarked image is proposed by Ishwarya.V et al. [10] to provide authentication for DICOM images. The proposed technique is based on PKI technique where an asymmetric watermarking is used. Using SHA hash function, hash value of the image is determined. The medical image is compressed using R-S vector. Then the watermark is created by combining SHA hash value, patient id and the compressed R-S vector. This watermark is embedded into the image matrix. For authentication of DICOM, the image file is extracted and the R-S vector, hash value are extracted. The performance of proposed method is evaluated using the quality measures PSNR, SNR, MSE and BER. Results show that the proposed scheme is an efficient watermarking technique for secure transfer of data.

III. CONCLUSION

Based on this survey, it can be concluded that there exists various medical image watermarking algorithms for securing DICOM files. Every method focuses on qualitative improvement in medical imaging with advancement in watermarking. It was shown that the watermarking assures the authenticity and integrity of a medical image. Watermarking in Medical imaging can be further enhanced in the direction of localizing the tamper with the malicious attacks.

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