ROI Lossless Colored Medical Image Watermarking Scheme with Secure Embedding of Patient Data

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***Abstract*—Transmission of images via internet and it's authentication is of great importance with the booming techniques in the field of networking and information security. Medical imaging and it's secure transmission have grown up as a necessity. This paper focuses on reversible watermarking of medical images, both grey scale as well as color, preserving its ROI. It also effectively manages patient health record by securely embedding it inside the image before transmission which facilitates better archiving of data with comparatively lesser transmission bandwidth and much lesser chaos. This paper considers noisy and noiseless environments as different cases with different implementation for both. Also tamper detection and recovery of ROI makes this quite a useful technique in the upcoming color imaging era.**

Keywords*—ROI, Reversible Watermarking, Authentication, Integrity, Patient Health Record, LSB, Noisy and noiseless transmission, AES, SHA-256, Adaptive Arithmetic compression, Noise filtering, Tamper detection and recovery.

I. Introduction

With the rapid growth of internet there has been an immense advancement in the context of networking. Transmission of all types of media files like audio, video and images occur as a common day-to-day affair. The key factors that is to be considered while transmitting media files like audio, video and images includes authentication, integrity and confidentiality. Among the wide range of media files, this paper concentrates on the medical images which are shared with other hospitals for catering several needs such as tele-conferencing, tele-diagnosis, to get a proper second opinion and so on. The above mentioned key factors should strictly be assured in case of medical images for ensuring proper diagnosis.

Medical images consist of Region of Interest (ROI) which comprises the most important region in the medical image for diagnosis. The remaining portion is called Region of Non Interest (RONI). ROI part need to be recovered without any loss at the receiver end. Patient health record is the collection of all details regarding the patient that are normally stored in the hospital database which may contain patient id, age, test, diagnosis, treatment so on. Both the ROI of the medical image as well as the Patient Health Record can be collectively used at the receiver side.

It could be an added advantage if both can be made available together which reduces the transmission as well as storage cost. It also helps to reduce the confusions of mismatch that could occur if stored separately.

LSB method, the commonly used spatial domain technique, is the most suitable one for medical images. It can provide more hiding capacity and is much simpler to implement when compared to other techniques. This method works by replacing the LSB of the selected pixels of the host image with the necessary values. Visual degradation caused is much less in LSB method as the changes to LSB's are not perceptual to human eyes. Many conventional watermarking techniques embed watermark into the host image at the cost that host image cannot be properly recovered. This is not acceptable for medical images. But, as not the entire host image is needed as such, the ROI alone could be made reversible and hence the term ROI lossless. Tamper detection and its recovery is needed in case it happened to the ROI. So all the necessary details for recovering ROI safely, should also be watermarked into the image.

Most medical images available here now are grey scale and eventually it will turn out to color images. So both grey scale and color images need to be taken care of to make this method a more usable one, when medical images are considered.

Literature review with regard to ROI based medical image watermarking, tamper detection and recovery techniques, reversible watermarking are handled in the section 2. Section 3 deals with the proposed system which handles a few gaps in the already existing systems. Section 4 deals with the results obtained. Section 5 deals with conclusion and future enhancement scopes.

II. LITERATURE REVIEW

Several watermarking methods have been developed so far based on medical images each focusing on specific features. Zain et al described a scheme for authentication of DICOM images using the technique of reversible watermarking [1]. The method was ROI based and it performed embedding of hash value of the whole DICOM image into the RONI of the image. The authentication was performed at the receiver side by re-computing the hash value at the receiver side and comparing with the extracted embedded value to check if any intentional or unintentional attack has occurred. This method lacked the feature of security which could be enhanced using any cryptographic techniques and also more data embedding could be made possible by adding

any compression techniques. Zain et al in his another paper suggested a method [2] which could provide more security, by randomly embedding in the RONI using equations and also by generating key for hashing in a randomized way. This method lacked any additional information regarding the patient i.e Patient Health Record which could make this method a more attractive one and also the study of noise immunity.

A method using multiple watermarking [3] was suggested by Kurniawan et al which incorporated the ideas of both robust and fragile watermarking. Two different watermarks namely signature watermark and reference watermark were used. This is also ROI based and the embedding of signature watermark was performed at the RONI and the other watermark was embedded in the ROI using Hash Block Coding (HBC) method. Its testing was highly focused around the level of robustness of the signature watermark and the fragility level of the reference watermark. The method resulted in a high quality image. Malicious attack could be used for further testing.

Watermarking of medical images using spiral numbering for recovering attack [4] was suggested by Hisham et al in his paper. It was mainly aimed at proposing a watermarking scheme by conducting a research on the area of tamper detection and recovery. This method considered image as a whole and made use of spiral numbering starting from the center of the image outwards for watermark insertion using chosen equation. This technique used spatial domain watermarking by using LSB method for watermark embedding. They performed inspection based on block based approach and also double checking for detecting tampers. Operating time was less but it worked only on grey scale images.

Sudeb Das et al in his work tried to provide solution to many issues in relation to distribution and management of medical data [5]. The technique incorporated ROI based watermarking taking into consideration tamper detection and it's recovery in the ROI. Electronic Health Record was also taken into consideration. Even though it was tested for different modalities, grey scale images were only considered. The technique covered several security aspects by incorporating cryptographic techniques but the effect of noise attack during transmission was not covered.

Electronic health record and the mean intensity value of ROI were used in the scheme developed by Abhilasha Singh et al[6]. The mean intensity was used with the intention of tampering malicious attack of replacing ROI with another one. The data was inserted into the RONI region. This technique done the isolation of ROI and RONI and was highly sensitive to attacks. This had the drawback of being tested only for lung CT scan images and also for not handling recovery process.

III. PROPOSED SYSTEM

The proposed system works for color as well as grey scale images and is implemented with respect to both noisy and noiseless environment. Doctor does the ROI marking by deciding which portion of the image is significant with respect to the current case under consideration. First, color images in noiseless environment using algorithm similar to the one used for grey scale images by Sudeb Das in his paper [5] is considered. The system consists of two different watermarks at the two LSB planes Bp and Bp+1. Steps in generating first watermark that is to be embedded in the bit plane Bp+1 is as follows.

Input: Color Medical Image, Patient Health Record.
Output: Color Medical Image with watermark1 embedded.

- Divide the image into ROI and RONI by drawing directly over the image using mouse clicks at locations where the ROI need to be marked.
- Take the hash of ROI using SHA-256 for making comparison to see if any modifications have occurred.
- Extract the bit planes Bp+1 and Bp of ROI for recovery procedure at the receiver end.
- Encrypt the patient data which consist of fields like patient name, case history, diagnosis, tests, treatments etc using AES algorithm.
- The encrypted data, hash of ROI, extracted bit plane values, vertices formed while creating ROI are all converted to appropriate internal representation and then concatenated for framing watermark1.
- The concatenated string is then compressed using Adaptive Arithmetic Coding algorithm and then embedded in the penultimate bit plane in scattered fashion using some predefined equation.
- The above mentioned steps except marking of ROI are performed individually for Red, Green and Blue components separately and done scattered embedding using the same equation as mentioned above into respective color components.

Steps in generating and embedding second watermark in the bit plane Bp is as follows.

Input: Color Medical Image with watermark1 inserted.
Output: Watermarked color medical image ready for transmission.

- LSB of the pixels of the image is set to zeros.
- The entire image is to be divided into 3x3 sized blocks.
- Hash value of each block is taken using SHA 256 and 9 bits our of each hash value are chosen using some predefined pattern and inserted into the LSB's of the corresponding 3x3 block.
- Repeat the above step for all the 3x3 blocks.

The second watermark could be used for locating whether tamper has occurred. Now the image is watermarked and ready to be transmitted. At the receiver side the same process is done in reverse order. The second watermark is extracted and compared to check if any tamper occurred and if tampered, where the tampering has occurred. The first watermark could be extracted for retrieving the ROI details and also the details regarding the patient for making diagnosis.

In a noisy environment, the procedure is same as the above except that there is a noise addition (salt and pepper noise in this case) happening at the transmitter side and a filter for removing noise at the receiver end. As the noise and filtering cause distortions to the embedded data, proper recovery of embedded data is not possible. This scheme recovers the ROI without visual degradation in most of the images, even though patient record becomes irretrievable in noisy environment.

Overall Block diagram in colored environment with noise addition and removal could be depicted as in the Fig 1.

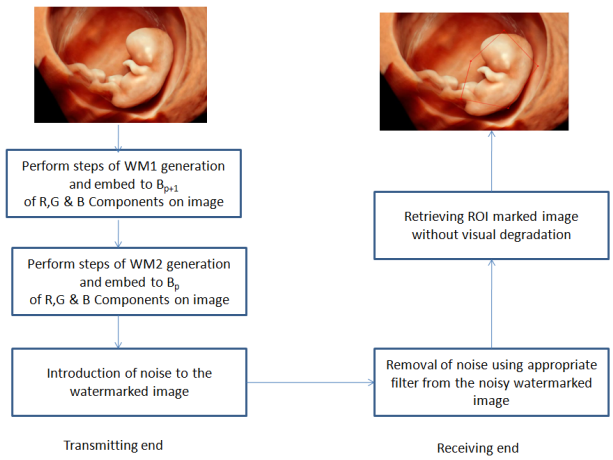

Fig. 1. Overall Block diagram for a colored image with noise addition

IV. RESULTS

A java program was developed in NetBeans to simulate the working of the proposed system. The program separately handled the two cases of noiseless and noisy environments for both grey scale and color images. Noiseless environment gave perfect results by correctly recovering the exact Patient Health Record and also by properly marking the ROI in the medical image for diagnosis at the receiver side. This is depicted using Fig 2.

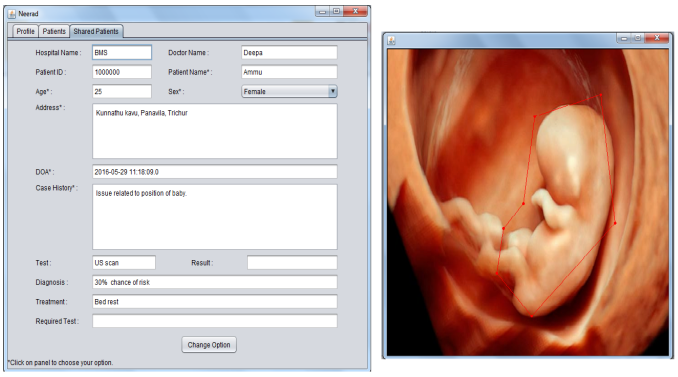

Fig. 2. Patient Data and ROI marked image at receiver side

The noisy environment tested with salt and pepper noise even though resulted in the distortion of the patient data, could properly retrieve the ROI in most of the cases without perceptual degradation in grey scale and its percentage of data loss is also calculated using PSNR value. Noisy environment created watermarked image and the ROI marked image obtained at the receiver side is depicted in Fig 3 and Fig 4 and the performance analysis for a few reference images shown in 5a, 5b and 5c is shown in Table 1. In general, acceptable PSNR values for images ranges from 30 to 50 db, which has been satisfied by all the test cases considered.

Fig. 3. Watermarked image after addition of salt and pepper noise

Fig. 4. ROI marked image at the receiver side after noise removal

Fig 5a

Fig 5b

Fig 5c

Fig. 5. A few images used for testing

TABLE I. COMPUTED PSNR VALUES

Sl. no.	Image	PSNR
1	Fig 5a	36.66
2	Fig 5b	49.64
3	Fig 5c	34.99

V. CONCLUSION

The results reveal that the technique works well for both colored and grey scale images in noiseless environment by marking the ROI and by correctly retrieving the patient health record at the receiver side. In noisy environment the method works well by properly recreating the ROI portion without visual degradation at the receiver side for most of the colored and grey scale images but it cannot retrieve patient health record as it get affected by the noise attack and the filtering process used to remove the attack. This technique is only ROI lossless which is not a highlighted drawback as only ROI is significant for medical images. The technique could be made an excellent one to be used in medical industry if the recovery of patient health record under noisy circumstance could also be taken care of.

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