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BLIND HYBRID WATERMARKING FOR SECURITY OF MEDICAL IMAGES

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ABSTRACT

In the proposed work a sightless robust and secure watermarking for image is planned by utilizing discrete wavelet transform (DWT) and Schur transform. In this proposal by exploiting DWT on the part of RONI (region of non interest) of the medical image, dissimilar sub bands of frequency of wavelets are obtained. Schur transform is employed on the LH sub band of the RONI, to attain dissimilar singular matrices. Of these chosen blocks ensemble of features with related values is recognized from the singular value matrix which lie at the left part. These pairs of values are adapted utilizing a threshold to insert the watermark. To attain the quality of image besides the robustness of medical image as well as content of watermark, suitable threshold is selected. Two watermarks, an image type and a text type which have been employed for the identification of original medical 2D data. The text watermark corresponds to the electronic record of the patient (EPR) for identification and the other watermark which is taken as image presents authentication. As a result of the amalgamation of DWT and Schur transform, this proposal offers improved visibility of watermarked image along with recovered content of watermark. With the projected scheme, watermark bits are extorted effectively even after withstanding a variety of attacks. Performance assessment of projected scheme with accessible schemes illustrates that the robustness is improved in the anticipated scheme against dissimilar kinds of attacks.

Keywords: Electronic patient record (EPR), Blind watermarking, Error correcting code, Schur transform, Authentication, Medical image security.

INTRODUCTION

Advancement in digital and information technologies has boundless novel chances in the zone of telemedicine where digital medical images as well as EPR are spread over links for medical exploration and analysis [Davie et al., 2001]. In telemedicine, inaccessible broadcast of image which is under medical supervision is essential towards affording instantaneous proven elucidation of patient's ailment. Now and then, complete test image or portion of it could be customized otherwise worsened through cyberpunks. The moral and legitimate problems in addition to controlling the privacy and reliability along with malpractice responsibilities can be surmounted by exploiting a digital watermarking [Nyeem et al., 2013, Parah et al., 2015]. Contrary to delicate watermarking [Dadkhah et al., 2014, Karthick, et al., 2017] robustness which is the important possession of water marking scheme entails resistance aligned with a variability of deliberate and inadvertent mass media handling, identified as assaults. According to the standard of digital imaging and communications in medicine (DICOM), watermark image accompanied by the EPR is necessary to be conversed genuinely. Such EPR data [Menon, et al., 2011, Singh, et al., 2015], with less error probability can be extorted through the digital watermarking. Special care is desired in water marking involved with medical images when information of the patient is inserted into the image which is under supervision as inserted information could disturb its pictorial excellence besides creating complication for surgeons to carry out apt identification by Kumar et al., [2011]. Dissimilar health image modalities such as X-ray, ultrasound, MRI, CT-scan, mammogram, etc. are utilized for images under medical supervision by Swaraja et al., [2017].

The data in images under medical supervision is unequally disseminated [Ansari et al., 2015]. ROI includes more useful portion of the image under medical supervision, and is exploited at the time of examination. RONI portion is not taken while examination. Both portions have diverse features and prerequisites. As a result, special categories of watermarks are inserted towards the objective of watermarking. The procedure of watermarking has to maintain the ROI unharmed, as deformation sources to incorrect investigation. The portion of RONI is utilized for inserting the watermarks [Cox, et al., 2002].

Watermark insertion is accomplished both in spatial domain and transform domain [Badshah et al., 2016]. In the watermarking techniques utilizing spatial domain, the watermark is inserted straightly by altering the values of the pel of the host image ensuing in small calculation intricacy. Least Significant Bit implanting, spread spectrum are few of the widely practiced schemes under spatial domain. Spatial schemes centered on spatial domain are delicate. However, this delicateness is beneficial during identifying the inaccurate part in addition to replica of test cover image from the distorted test image [Ansari et al., 2015]. Watermark is inserted in transform domain methods, by altering the coefficients of the cover image under test. DWT- DFT- DCT and SVD remain as frequently exercised transforms. Transform domain methods are relatively more robust [Kumar et al., 2011]. All transforms have dissimilar characteristics in addition to dissimilar illustration of the cover image. Few transforms might withstand to some group of attacks while few other transforms do not withstand to the same attacks and may withstand to some other attacks. Mousavi et al., [2014], Nyeem et al., [2013] and Lai et al., [2007] Unsighted water marking method is planned in this paper aimed at range of images which are under supervision utilizing Schur transform by exploiting the LH sub band of DWT of the test image. The amalgamation of DWT and Schur is practiced in the projected algorithm which suggests the content of watermark (image and EPR data) resilient when weighed against the accessible schemes.

In addition, the unsighted method is indiscernible and the retrieval of watermark is made easy. Section 3 includes the planned work while in section 4 experimental outcomes and discussions were analyzed. At last, the conclusions are specified in section 5.

RELATED WORK

A semi-blind DWT based watermarking idea is proposed by Yadav et al., [2015], where the LL sub band of cover image is alienated into 8 × 8 non-overlapping block. According to entropy and using assured weight aspect of these blocks which is resoluted by customary deviation, the bits of the water mark are inserted into it. Chen et al., [2013] proposed Semi-blind watermarking is projected established on discrete wavelet transform (DWT) besides compress sensing (CS). While inserting the watermark into test image, the singular values (SVs) of HH sub band of cover image are restored with the SVs of CS constituents of watermark image. Netty Ermawati et al., [2017] unsighted watermarking technique using error correcting code (ECC) based on DWT-DCT is anticipated which suggest improved toughness in contrast to variety of assaults. Hybrid method established by SVD, DWT in addition to DCT is planned to acquire better imperceptibility and robustness [Singh et al., 2014]. The information of the dual watermark (image and encrypted text) is inserted into medical image by means of DWT [Singh et al., 2015 and. Maheswari, et al., 2017]. A reversible watermarking scheme by exploiting DWT-SVD along with differential evaluation (DE) is projected for medical images. It is asserted that the proposal recommended fine steadiness between capacity, robustness and imperceptibility. In E-healthcare system, a watermark image and electronic patient record (EPR) are inserted into a few blocks of DCT coefficients of original medical image [Parah et al., 2015]. In favor of telemedicine application, a spread spectrum based MIW in DWT domain is executed to attain higher safety and robustness. In protected and fragile watermarking technique [Kumar et al., 2011] Integer wavelet transform (IWT) is exploited to evade fractional calculations.

In this work, a blind and robust watermarking method is proposed for a variety of medical images. The scheme is robust in opposition to JPEG compression, rotation, geometric and filtering types of attacks. To make it appropriate for telemedicine applications, dual watermark contents are inserted into RONI of the medical image. For authentication purpose watermark image is used while the text water mark is the EPR data enclosing name, registration and other details of patient. While inserting the water mark, ECC is applied on the EPR data and Arnold transform on watermark image to lessen the error. To execute the scheme, Schur transform is applied on the blocks of LH sub band with size 4 × 4. The upper triangular matrix of the Schur transform of each block are adapted to insert the watermark bits. At the time of watermark retrieval, blind extortion of watermark contents is attained using comparison of these elements.

PROPOSED SCHEME

It is because of necessity of extremely imperceptible watermarked image which is essential for correct diagnostic and robust extortion of watermark bits. Moreover, EPR data including patient particulars which include name, date, registration number together with watermark image which is used for authentication is required to insert into the medical image [Singh et al., 2015]. Unsighted scheme of watermarking with DWT-Schur transform is projected in this paper. Here, DWT in company with Schur builds the scheme more imperceptible and exceedingly robust aligned with a range of attacks. When DWT is applied on RONI of the medical image, it generates dissimilar frequency sub bands: LL, HL, LH and HH. Schur transform is applied on the non-overlapping blocks of the LH sub band. While inserting the water mark, particular pair (upper triangular matrix) of Schur coefficients of certain number of blocks is adapted according to the watermark bits. Thus, the scheme planned in this work practices the effects of U matrix [Su and Niu et al., 2013] in conjunction with element alteration method [Parah et al., 2015] in DWT domain for blind retrieval of watermark bits. In compliance with the watermark bits, the specific pair of features of U matrix of preferred block in wavelet sub band LH of RONI is customized. We recognized that, such blind extortion performs well in opposition to the majority of attacks and offers superior imperceptible watermarking. Thus, the proposal acquires the benefits of characteristic of Schur and DWT to execute better when watermark is inserted in LH sub band of RONI. Here, RONI is chosen manually as pentagon shape. Here, LH sub band of the RONI is changed into 4 × 4 non-overlapping blocks and Schur transform is employed on all blocks to engender V, T and V^T matrices. It is recognized that, there is a much slighter divergence among the elements of V matrix at position (1,1) and (2,1) in the RONI of LH sub band of medical image. Thus while inserting the watermark, these elements are preferred and adapted according to the watermark bit. This is specified in the subsequent subsection.

For authentication and identity of the respective medical image, multiple watermarks are inserted into the medical image. Image watermark bits presents authentication to the user. This watermark is extorted by user through the secret key (position of adapted elements). Actually, hospital logo as watermark image is inserted for ownership authentication. Another watermark is text watermark which includes the detail of the patient name, registration number, disease type, date on which he/she is admitted in hospital etc. By medical society this is acknowledged as EPR. Such features are essential in hospital database to categorize the dissimilar test images of individual patients to evade the faulty diagnosis. Consequent EPR data is inserted into the medical image which includes doctor code, image number from the database of the hospital and patient information. To lessen the retrieval error in the extorted text (EPR), the BCH error correcting code (ECC) is exploited at the time of inserting into the medical image.

A. Watermark embedding procedure

In this scheme, the elements V (1,1) and V (2,1) of matrix V of certain block of LH sub band of RONI have been exploited. The relative deviation among chosen coefficients V (i, j) are modified in accordance with the watermark bits. The procedure for inserting the watermark bits '0' and '1' is given below.

Algorithm for inserting watermark bit '0':

```
If (V (1,1) ≤ V (2,1)
   swap V (1,1) ,V(2,1);
end
If ((V(1,1) −V(2,1)) < μ
     V(1,1) = V(1,1) + ‾ ;
     V(1,1) = V(1,1) − ‾ ;
end
```

Algorithm for inserting watermark bit '1':

```
If (V(1,1) ≥ V(2,1)
   swap V(1,1) ,V(2,1);
end
If ((V(1,1) −V(2,1)) < μ
     V(1,1) = V(1,1) − ‾ ;
     V(1,1) = V(1,1) + ‾ ;
```

In the above algorithm, 'μ' correspond to the watermark weight factor or threshold entailed during inserting the watermark. The choice of threshold assessment 'μ' is based on the average variation of recognized Schur coefficients of V matrix of LH sub band. Threshold 'μ' is based on the average variation of V(1,1) and V(2,1) elements. The value of 'μ' would not amend the original values to a large extent and directs to improved imperceptibility of watermarked medical image. The steps to insert watermark image and EPR data into RONI of the medical image are as follows Read the electronic patient record (EPR) along with watermark image.

1. Generate the binary sequences of watermark image as well as EPR data.
2. BCH Error correcting code (ECC) is applied on the binary sequence of EPR data and Arnold transform is applied on the watermark image then this coded sequence is inserted into the medical image.
3. Apply 2D discrete wavelet transform (DWT) on the selected RONI which generates dissimilar frequency sub bands: LL, HL, LH and HH.
4. Split the LH sub band into non-overlapping blocks of size 4 × 4. Schur transform is employed blockwise to engender three matrices V, T and V^T per block.
5. By exploiting the threshold 'μ' insert the water mark bits into the V matrix by amending the chosen elements V(1,1) and V(2,1) of the preferred blocks with dimension 4 × 4 of LH sub band.
6. The value of V(1,1) is made larger than V(2,1) while inserting the watermark bit '0' in image, whereas the value of V(1,1) is made less than V(2,1) while inserting the watermark bit '1'. Reiterate this step until the last bit of watermark data.
7. Inverse Schur of each block is found to retrieve the adapted sub band LH.
8. Inverse DWT is applied on the adapted sub band LH along with LL, HL and HH sub bands to acquire customized RONI.
9. Grouping of this adapted ROI and RONI produces the watermarked image.

B. Extraction procedure of EPR and watermark image

1. From the noisy watermarked image RONI is extracted.
2. DWT is implemented onto the selected RONI image to acquire the sub bands LL, HL, LH and HH.
3. Schur transform is applied on the non-overlapping blocks of LH sub band of RONI.
4. Recognize the blocks in which the watermark bits are inserted.
5. The extorted bit is regarded as '0' in a block, if the value of V(1,1) is greater than V(2,1), otherwise it is regarded as '1'.
6. To reconstruct watermark image the binary sequence is reshaped.
7. To obtain original EPR data and watermark image an extorted coded binary series associated to EPR data and watermark image is decoded by proper decoder.

EXPERIMENTAL RESULTS AND ANALYSIS

The projected method is tested for variety of medical images such as Ultrasound, MRI, CT scan, mammogram, PET and X-ray images. The medical MRI Image of size 512 ×512 as original image, the watermark image of size 256 × 256 and 128×128 is considered as text watermark (patient's information) and image watermark (hospital logo) respectively while simulation. The protection of the text water mark image is boosted by exploiting BCH error correcting code prior to inserting into the original medical image. In addition, Arnold transform is applied on the hospital logo to increase the authentication for correctly retrieving the watermark during diagnosis. For testing the robustness of the retrieved watermarks (both image and text) and the imperceptibility of the watermarked medical image, MATLAB is executed. Figure 1(a) and (b) shows the text watermark and image watermark respectively which are inserted during watermarking procedure. To embed these bits of watermark contents, LH sub band of RONI are used.

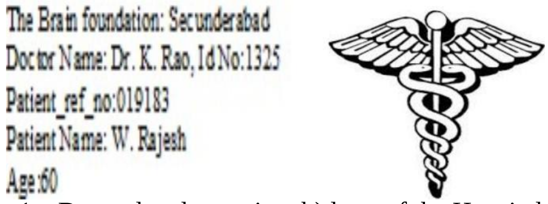

Fig. 1a: Data related to patient b) logo of the Hospital

A. Performance measures

Peak signal-to-noise ratio (PSNR), is utilized to evaluate imperceptibility between original and water marked medical images. The PSNR is specified in equation (2). A PSNR is delineated through mean square error (MSE) by calculating the inaccuracy among original and watermarked image. A formula for the same is given in equation (1)

$$MSE = \frac{1}{R \times C} \sum_{i}^{R} \sum_{j}^{C} [V(i, j) - V'(i, j)]^2 \qquad (1)$$

In equation (1), V and V' are the originally watermarked with medical images respective to the measurement R × C. The principle of PSNR in decibels (dB) by means of MSE is specified in the equation (2).

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

The robustness analysis among extorted watermark and original watermark bits is executed using bit error rate (BER) and normalized correlation coefficients (NCC) which are delineated by subsequent equations (3) and (4).

$$BER(O, R) = \frac{\sum_{i=1}^{R} \sum_{j=1}^{C} O(i, j) \otimes R(i, j)}{R \times C} \qquad (3)$$

In equations (3) & (4) the 'O' and 'R' signifies the original and extorted watermark bits respectively whereas R×C is the dimension of the same.

$$NCC(O, R) = \frac{\sum_{i=1}^{R} \sum_{j=1}^{C} (O_{ij} - O)(R_{ij} - R)}{\sqrt{\sum_{i=1}^{R} \sum_{j=1}^{C} (O_{ij} - O)} \sqrt{\sum_{i=1}^{R} \sum_{j=1}^{C} (R_{ij} - R)}} \qquad (4)$$

B. Imperceptibility & Robustness

The Implementation of the hybrid DWT-Schur watermarking technique has been judged with regard to the imperceptibility (PSNR) and sturdiness of the watermarked image (NC). Test image as well as watermarked MRI Images are depicted in Figure 2(a) and (b). The PSNR as well as NC assessment of the anticipated technique is given away in Table 1. Table 1 illustrates the PSNR as well as NC assessments of the planned method without attacks for six dissimilar medical images. The maximum NC value 1 has been attained with MRI image. Conversely the lowest NC assessment is 0.89 aimed at X -RAY image. PSNR as well as NC assessments of the anticipated algorithm have been estimated with various kinds of attacks. The highest PSNR value acquired even after attacks is 50.3 dB also NC assessment is 0.92. Table 2 illustrates the evaluation of the PSNR as well as NC values of the planned algorithm. The highest NC assessment achieved by the Singh et al. is 0.9. Conversely, the highest NC assessment gained through the planned algorithm is 0.81. Thus. the planned method suggests higher robustness and imperceptibility.

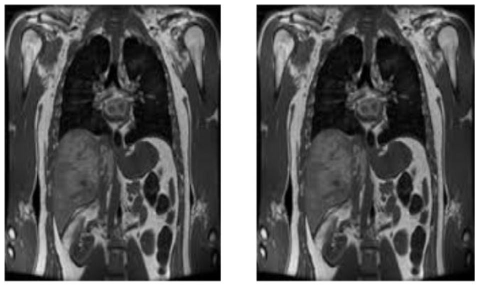

Fig. 2a: MRI test image b) MRI image after watermarking

Table 2: Comparison of PSNR and NC results for MRI Medical Image

Medical Images	PSNR (db)	NC
Ultrasound	51.2	0.9
MRI	52.9	1
CT	50	0.92
Mammogram	49.47	0.93
X-RAY	55.13	0.89
PET	45.6	0.91

Attacks	PSNR (db)	NC	PSNR (db)	NC
Resizing	50.30	0.91	47.12	0.89
Rotation	49.41	0.92	45.03	0.9
Cropping	48.57	0.91	46.98	0.9
JPEG Compression	49.93	0.84	47.99	0.78
Sharpening	49.82	0.81	50.10	0.79
Averaging	50.17	0.85	48.78	0.81
Salt &Pepper noise	48.95	0.89	43.45	0.80
Gaussian noise	50.19	0.90	42.89	0.85

CONCLUSION

In this scheme, a blind medical image watermarking technique is projected for inserting multiple water mark data. These watermarks offers authentication in addition to identity. watermark image is utilized for authentication while the record of electronic patient (EPR) is exercised for uniqueness of the image under medical supervision. On EPR data an error correcting code (ECC) is employed towards increasing robustness prior to inserting into the image. After tests it is identified that the property of left singular matrix is apt as well as well-organized in the RONI of the image under medical supervision. Consequently, in the planned work while embedding, wavelet sub band LH of RONI is alienated into no overlapping blocks of size 4 × 4 further Schur transform is exploited.

Subsequently, chosen pair of matrix with singular value at the left side of blocks is altered in accordance with the preferred embedding bit of water mark. As a result, during extortion, location of the blocks is only required wherein such features adaptation are formerly carried out. When adapted features, go behind specific ailments, at that moment extortion of watermark data is one or else zero. Though, the watermark bits be inserted into the RONI of the image under medical supervision, the indiscernibility of the planned work stands superior by attaining the PSNR value beyond 45 dB. Additionally, sturdiness recommended by the projected method is likewise enhanced in contrast to accessible methods beneath different sorts of assaults. Analysis of error correcting code with BCH aimed at encoding the EPR data besides Arnold transform for watermark image shows the better performance even under a variety of attacks.

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