Robust and Imperceptible Region Based Watermarking on Medical Images

K. Swaraja, K. Meenakshi, Padmavathi Kora, and G. Karuna

Abstract Telemedicine is the remote delivery of health care services to evaluate, diagnose and treat patients using common technology, such as video conferencing and smart phones, without the need for an in-person visit. There is likelihood in altering the medical images purposely or unintentionally while transmitting over covert channel. The Physician confirms the diagnosis region obtained from the medical image as region of interest (ROI), prior to interpreting any report on evaluation. Watermarking scheme for medical images exploring DCT domain is conferred in this proposal. Fuzzy c algorithm is utilized in segmenting the assessment region (ROI) and non-interest region (RONI), further the watermark is inserted through modulation scheme termed as M-ary. The scheme efficacy is determined for MRI medical images through simulation by computation of quality metrics such as PSNR and NCC.

Keywords Medical image watermarking · Region of interest · Fuzzy c-means · M-ary modulation

1 Introduction

Internet is the most innovative improvement in the existing technology. In our existence, health care is the most significant application of internet to health concern providers as Electronic Patient Record (EPR) is transferred to dissimilar organizations. The watermarking schemes in the telemedicine area [1–3] entail extreme caution while inserting extra data inside the medical images as the added data need not distress the quality of the image. Therefore, to overcome the difficulty of memory exploitation as well as to defend the medical details against illicit handling, watermarking for medical images is employed. Thus in this work, a watermarking system exploiting the M-ary modulation scheme is proposed. The image with medical details

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is separated into regions termed as assessment region (ROI) and non-interest region (RONI) after the confirmation given by Physician or Surgeon from the Diagnosis. ROI is extorted by Fuzzy C-means procedure, moreover the electronic record of the patient taken as watermark is inserted in non-interest region by means of M-ary modulation into the mid-band frequency coefficients of DCT. Thus, this modulation procedure is selected prior to the insertion of watermark to augment the security and covertness of the details in the medical image.

Rest of the work is organized consequently: Related effort concern to watermarking schemes is presented in Sect. 2 in the area of medical field. In Sect. 3 M-ary modulation is illustrated. The Proposed scheme is discussed with regard to ROI extraction along with the procedure of insertion and extraction of the watermark in Sect. 4. Simulation results are analyzed in terms of PSNR and Normalized Correlation (NC) in Sect. 5. Lastly, the given proposal is concluded in Sect. 6.

2 Related Work

There are several watermarking techniques of image [4, 5, 11] and video [12–15]. Inserting details of the patient into the modalities of medical image for diagnosis purpose is termed as Medical Image Watermarking scheme and it is ought to be robust in life. Swaraja et al. [3] projected data concealing of electronic record of the patient (EPR) into the test image to offer secrecy, reliability along with authenticity to electronic record of the patient details. These details might be related to diagnosis, ECG signals otherwise a signature preserved digitally with regard to physician, as a choice hospital emblem. The surgeons signature which is recorded digitally as well as the emblem of hospital can be utilized for authentication of electronic record of the patient. To attain secrecy, electronic details of the patient can be decoded. Lee et al. [16] projected watermarking scheme based on DWT to avert illicit misrepresentation. The watermark which includes the particulars of Patient is concealed into RONI to make the diagnosis perfectly. Li. et.al [17] projected medical image watermarking by means of IA-W watermarking to find the source of an invalid discharge of medical test images within the multicast atmosphere. Navas et al. [18] projected data concealing scheme for EPR which is invertible on CT brain images by utilizing integer wavelet transform (IWT). To obtain additional protection for medical images, EPR detail is concealed into RONI further ROI is selected randomly with a rectangular shape. Guo et al. [19] projected a ROI watermarking process for medical images which is lossless by exploiting Difference Expansion scheme in which the watermark is inserted into RONI whereas ROI as.

a polygon is selected physically. Dhavale et al. [20] projected safe transfer of medical images by exploiting Discrete Cosine Transform (DCT) as well as Least Significant Bit (LSB) replacement beside new (CDCS) for inserting details of the patient to augment concealing capability to present superior perceptual excellence of stago images. By applying this method if there is minor alteration of stago images either in inserting area or in ROI can be simply noticed at the receiver end.

3 Methodologies

M-ary Modulation
In digital communication the minimum entity used to represent data is termed with codes, however in case of binary signalling logic 0 or logic 1 are the two disparate codes.In case of M-ary (M > 2) signaling more than two dissimilar symbols are there. With regard to M-ary signaling method consider M feasible signals as $s1(t)$, $s2(t)$ … $s(t)$ moreover these signals can be passed on for each signaling that to for a scrupulous period of time *Ts*. Commonly, for all uses the probable count of codes can be signified as $M = 2^K$ where K is an integer. Spreading of data with regard to pass-band can be created through changing the amplitude and phase along with frequency of a sinusoidal carrier in M discrete steps, therefore ASK, PSK and FSK digital modulation methods are acquired. Dissimilar bandwidth ability next to the price of power efficacy could be attained with modulation techniques by exploiting M-ary.

M- PSK: With regard to modulation signals for M-PSK, it can be defined as given in Eq. 1.

$$R(t) = C\ \cos(2\pi f_c t + \theta_j + \theta'), \quad 0 \le t \le T \tag{1}$$

where, $\theta_j = \frac{2\pi}{M} j$.

for j = 0, 1, …, M − 1 where C is a constant and f_c is a carrier frequency. The initial phase angle is symbolized by θ′ and symbol period is signified by T. Equation 2 is acquired by expanding Eq. 1. Therefore,

$$R(t) = C\{\cos\theta j \cos(2\pi f ct + \theta') - \sin\theta j \sin(2\pi f ct + \theta')\} \tag{2}$$

Signal power can be symbolized as $P = \frac{C^2}{2}$ where $C = \sqrt{2P}$.
Then Eq. 2 can be written as

$$R(t) = \sqrt{PT\cos\theta j}\sqrt{\frac{2}{T}}\cos(2\pi f ct + \theta') - \sqrt{PT\sin\theta j}\sqrt{\frac{2}{T}}\sin(2\pi f ct + \theta') \tag{3}$$

$$R(t) = \sqrt{E\cos\theta j}\sqrt{\frac{2}{T}}\cos(2\pi f ct + \theta') - \sqrt{E\sin\theta j}\sqrt{\frac{2}{T}}\sin(2\pi f ct + \theta') \tag{4}$$

where $E = PT$ is the energy enclosed in a symbol interval. For ease, select angle θ′ to be zero and take $\varphi_1\, t = \sqrt{\frac{2}{T}}\cos 2\pi fc\, t$ and $\varphi_2\, t = \sqrt{\frac{2}{T}}\sin 2\pi fc\, t$ as the orthogonal basis functions from Eq. 3. The signal constellation figures for M-PSK modulation is depicted in Fig. 1 for M = 16.

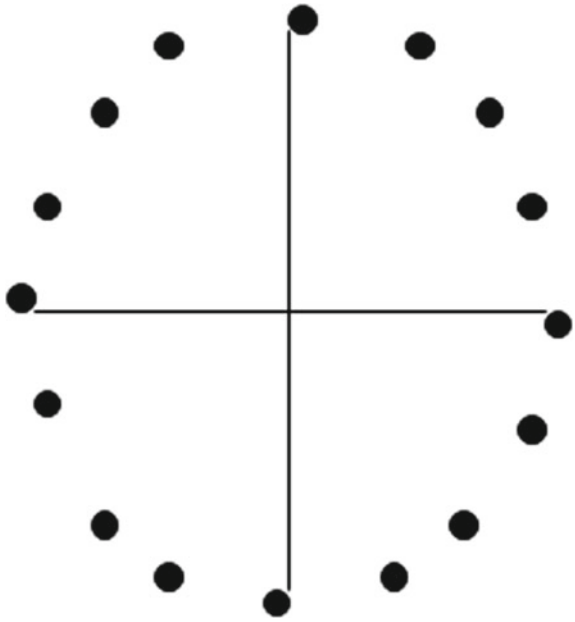


Fig. 1 Constellation diagram for M = 16

4 Proposed Scheme

Electronic record of the patient which is taken as a watermark in this work is inserted into the coefficients of mid- frequency band of DCT by implementing the M-ary modulation. During the process of inserting the watermark the scheme entails two stages, initially the assessment region (ROI) which is a portion to be diagnosed stands to be extorted by means of Fuzzy-C and furthermore, the electronic record of the patient (EPR) considered as a watermark is chosen to insert in the coefficients of mid frequency band of DCT by M-ary modulation within the non interest region (RONI).

4.1 Extraction of ROI

The portion of any medical image to be diagnosed which is termed as ROI includes useful information and so there is a need to be preserved without alteration. At present numerous segmentation schemes for image, tracked through morphological functions are there for extorting the portion of region to be diagnosed. The steps included for extorting the ROI from the host image are as follows.

- The image taken as input is a grey scale image.
- The algorithm which implements Fuzzy c-means is applied to get a binary image from grey scale image. Alignment of information starting with a big set to create a brief depiction is involved in Fuzzy clustering.

- To work out on automatic threshold value canny edge detection is applied to approximate the quantity of light as well as non-edge pixels of image.
- In this procedure, by applying Morphological functions the output image is attained based on evaluation of the consequent picture element in the input image with its neighbours. Binary mask can be produced by exploiting dilation and erosion function and acquired a white portion image which is called as ROI.
- RONI region is extracted by subtracting the ROI from the original image.

4.2 Watermark Embedding

The watermark considered in this work is an Electronic patient record which is inserted in the mid- frequency band of DCT coefficients. Primarily the RONI part is modulated with M-ary modulation prior to inserting the watermark. So as to develop the visual imperceptibility and robustness of the projected scheme, watermark is inserted in the middle chosen DCT coefficients [21]. The subsequent insertion process is discussed below:

Step 1: The grey scale medical image considered as cover image with dimension of 256 × 256 pixels is Interpreted.
Step 2: After segregating the test image into 8 × 8 block dimension, the DCT is applied to the cover image. Specific coefficients of DCT in the middle range of frequency are preferred while inserting the watermark.
Step 3: The watermark must not be inserted in the X and Y coordinates of region of interest (ROI) portion while selecting the precise coordinates.
Step 4: Towards improving the protection of the system, the scheme of M-ary modulation is executed on the watermark details, in addition these details are concealed in the mid- band frequency coefficients of DCT. The size of the watermark is 32 × 32 pels moreover modulation with 16-PSK is utilized.

4.3 Watermark Extraction

The detection procedure is a converse practice of concealing the watermark. The extortion steps include:

Step 1: The medical image which is watermarked, with dimension 256 × 256 pixel is to be taken.
Step 2: Watermarked medical image is converted into 8 × 8 pixels then DCT is applied on the RONI area.
Step 3: Extort the mid frequency coefficients from the tested position of the watermark.
Step 4: M-ary demodulation scheme is exploited.
Step 5: Watermark is retrieved.

5 Experimental Results and Analysis

Simulations were performed on dissimilar MRI medical images. Medical original images are of size 256 × 256 pixels and the watermark size used is 32 × 32 pixel. In the proposed work watermark is inserted in the non interest region whereas the diagnosis portion termed as ROI must persist safe. Herein the watermark insertion besides extortion is interpreted with M-ary modulation towards dissimilar MRI medical images. The watermark which is considered as the electronic record of the patient (EPR), with unusual MRI images is demonstrated in Table 1. To assess alteration among original image as well as watermarked medical image specific preset additive white Gaussian noise (AWGN) is adapted, in addition outcome is examined through assessing some performance constraints like: Peak signal to noise ratio (PSNR) for evaluating Imperceptibility and Normalized correlation for evaluating Robustness. The simulation outcome for Watermarked image in terms of PSNR and NC values [22] along with the recovered watermark for dissimilar MRI medical image modalities is depicted in Table 2. The deformation among the original medical watermark image as well as recovered medical watermark image is estimated pertaining to PSNR and Normalized cross correlation (NCC) and is depicted in Table 2. The complete explanation with formulae for PSNR and MSE along with NCC constraints was elucidated in [23, 24]

Table 1 Dissimilar MRI Medical Images and Watermark taken for simulation are exposed

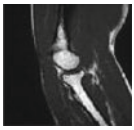
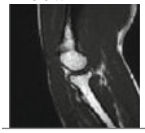
Image modality	Original MRI medical image	Watermark
Elbow		The Brain foundation: Secunderabad Patient_ref_no:019183 Doctor Name: Dr. K. Rao Patient Name: W. Rajesh Age: 65
Heart		The Brain foundation: Secunderabad Patient_ref_no:019176 Doctor Name: Dr. K. Rao Patient Name: S. Venkat Age: 65
Hips		The Brain foundation: Secunderabad Patient_ref_no:021517 Doctor Name: Dr. K. Rao Patient Name: S. Venkat Age: 65

Table 2 Watermarked MRI medical image Modalities with PSNR and NCC values along with recovered watermark for dissimilar MRI images

Watermarked MRI medical image modalities	Recovered watermark	PSNR (db) & NCC
Elbow 	The Brain foundation: Secunderabad Patient_ref_no:0191833 Doctor Name: Dr. K. Rao Patient Name: W. Rajesh Age: 65	65.6 0.98
Heart 	The Brain foundation: Secunderabad Patient_ref_no:0191762 Doctor Name: Dr. K. Rao Patient Name: S. Venkat Age: 65	64.3 1
Hips 	The Brain foundation: Secunderabad Patient_ref_no:0215179 Doctor Name: Dr. K. Rao Patient Name: S. Venkat Age: 65	63 1

6 Conclusion

Currently Tele diagnosis arrangement is admired in rural zones wherever medical check-up is tough to attain. In this work an image watermarking scheme is exploited by making use of DCT domain for dissimilar medical image modalities. The test image includes two regions ROI (diagnosis data) plus RONI. The diagnosis portion termed as ROI is extorted by fuzzy c- means technique and electronic record of the patient (EPR) as a watermark is to be inserted in mid-band frequency DCT coefficients utilizing M-ary modulation only on the RONI area. By exploiting M-ary modulation, the system robustness is enhanced through attaining improved values of PSNR with an average assessment of 64.5 dB and also recommends superior values towards the normalized cross correlation (NCC) of the extorted watermark.

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