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Research paper

Medical Image Watermarking Technique Using Image Interpolation in Transform Domain

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Abstract

In telemedicine, medical data are shared across the world among different specialists for various purposes through an unsecured medium. So there is a need to protect the medical data during transmission. With the help of image watermarking techniques, medical images are protected along with the electronic patient information (EPI). This paper proposes a medical image watermarking, by applying wavelet transform, using an interpolation technique. EPI data is embedded within the transformed medical image to generate a watermarked image. At the extraction side, EPI data are extracted and medical image is reconstructed without any loss. The performance of the proposed method is analyzed using a peak signal to noise ratio (PSNR), mean absolute error (MAE) and structural similarity index (SSIM). The experimental result shows that the proposed method gives better results.

1. Introduction

Now a days, data security is playing a vital role in a multimedia world. Information is transmitted from one place to another place and during transmission, there is a chance to attack the information. So information security is needed. Two main types of data hiding methods are stegnography and watermarking. In both the techniques secret data is embedded within other multimedia data like audio, image, video, etc. stenography concentrate only on the secret data and watermarking concentrate on both secret data and cover data[1]. In telemedicine applications, medical images are transmitted from one location to another location for diagnosis purpose with patient data. On the receiver side, the original medical image is needed without any loss for correct diagnosis. Hence the watermarking technique is the most suitable for telemedicine applications to transmit the medical images [19].
In medical image watermarking, patient information is embedded within a medical image and transmitted to the receiver. At the receiver side, the patient information is extracted from the received medical image and original image extracted without any loss [2,3]. Several types of image watermarking techniques are present [1]. Medical image watermarking is performed on spatial and transform domains [4,5,14-16]. For copyright's purpose, Dharwadkar et al [6] implemented a reversible medical image watermarking technique with zero tolerance in a noisy channel. In order to provide confidentiality, integrity, and authentication (CIA) Eldayem [7] proposed a reversible watermarking technique using adaptive encryption standard (AES) algorithm and message digest-5 (MD5). The hash value is generated using MD5 and the watermark is encrypted using AES algorithm. The encrypted watermark and hash value are embedded within a medical image. At the extraction side hash value is verified then the data is extracted and medical image is received.
In the spatial domain, the image size is modified using interpolation techniques to embed a secret data within a scaled image for reversible data hiding without affecting the original pixel values. The secret data is embedded within a cover image using nearest mean interpolation method (NMI) developed by Jung and Yoo [8]. The cover image is scaled up using NMI and scaled image is divided into a number of nonoverlapping blocks. Then the secret data is embedded within each block. Lee and Hunag [9] proposed an efficient reversible data hiding technique is proposed using neighboring pixels maximum difference values to hide the secret data to improve the embedding capacity. Wang et al [10] proposed a reversible data hiding by dividing the image pixels into two groups. In one group secret data is embedded using an interpolation error and in another group secret data is embedded using histogram shifting in order to increase the embedding capacity.
Using shearlet transform a robust watermarking technique is proposed by Mardanpour and Chachooki [11]. First, the image is divided into a number of subbands using shearlet transform. Using the singular value decomposition (SVD) watermark is embedded within a subband. Chetan and Nirmala [12] implemented robust image watermarking using integer wavelet transform (IWT). The watermark is coded using block level coding and embedded within a wavelet sub band of the image. Medical image watermarking is developed by Mehto and Mehra [13] using discrete wavelet transform DWT and discrete cosine transform (DCT). First, the image is decomposed using DWT, then for high-frequency subbands, DCT is applied. The watermark is embedded in DCT coefficients. Priya et al [17] proposed medical image watermarking using two transforms.IWT decompose the image into different subband and gould transform recover the medical image without any loss. Lossless image recovery is achieved by using interpolation based data hiding technique[19]. This paper proposes a reversible watermarking technique using the image interpolation technique in the transform domain.

2. Proposed System

In this section, an interpolation based medical image watermarking technique is proposed. The medical image size is reduced by half. Then the cover medical image is generated using integer wavelet transform (IWT). The size reduced medical image is decomposed into a number of subbands. Then each subband is scaled up to generate a cover image subband and patient information (watermark) is embedded within a cover image subband as shown in Figure-1.

The wavelet approximation subband of size mXn is scaled up using any interpolation technique of size 2mX2n. The other subbands are resized to 2mX2n by inserting one row and one column between two pixels. For example, consider high-frequency wavelet subband pixel at (i, j) position, then the cover image is generated by inserting one pixel right to that pixel and one pixel down to that pixel also insert one pixel in a diagonal direction between two subband pixels using the following equations.
Let I be the high-frequency subband and C is the interpolated cover subband.

$$C(i, j) = I(i, j) \quad (1)$$

$$C(i, j+2) = I(i, j+1) \quad (2)$$

$$C(i+2, j) = I(i+1, j) \quad (3)$$

$$C(i+2, j+2) = I(i+1, j+1) \quad (4)$$

then the interpolated subband pixel value is calculated by using the following equations

$$C(i, j+1) = |I(i, j) - I(i, j+1)| + I(i, j) \quad (5)$$

$$C(i+1, j) = |I(i, j) - I(i+1, j)| + I(i, j) \quad (6)$$

$$C(i+1, j+1) = (C(i, j+1) + C(i+1, j) + C(i+2, j+1) + C(i+1, j+2)) / 4 \quad (7)$$

After the interpolated pixels are identified for the subband, the difference (diff) between the interpolated pixel with the maximum value of the original pixels is calculated. Based on the difference (diff) value the length (l) of the embedded secret data is calculated. The watermark (wk) value is calculated from the corresponding decimal value of the binary secret data. Then it is added with the interpolated pixel. This embedding process is represented using equations 8-12.

$$\max = (c(i, j), c(i, j+2), c(i+2, j), c(i+2, j+2)) \quad (8)$$

$$diff = |\max - c(i, j)| \quad (9)$$

$$l = \log_2(\text{diff}) \quad (10)$$

$$wk = \text{decimal}(l \text{ bit secret data}) \quad (11)$$

$$C' = C + wk \quad (12)$$

Finally, inverse integer wavelet transform is applied to generate a watermarked medical image (W). It is transmitted to the remote specialists. At the receiver side, by repeating the watermark embedding process the secret data is extracted and original image is reconstructed without any loss. Algorithm 1 shows the proposed watermarking technique embedding and extraction procedure.

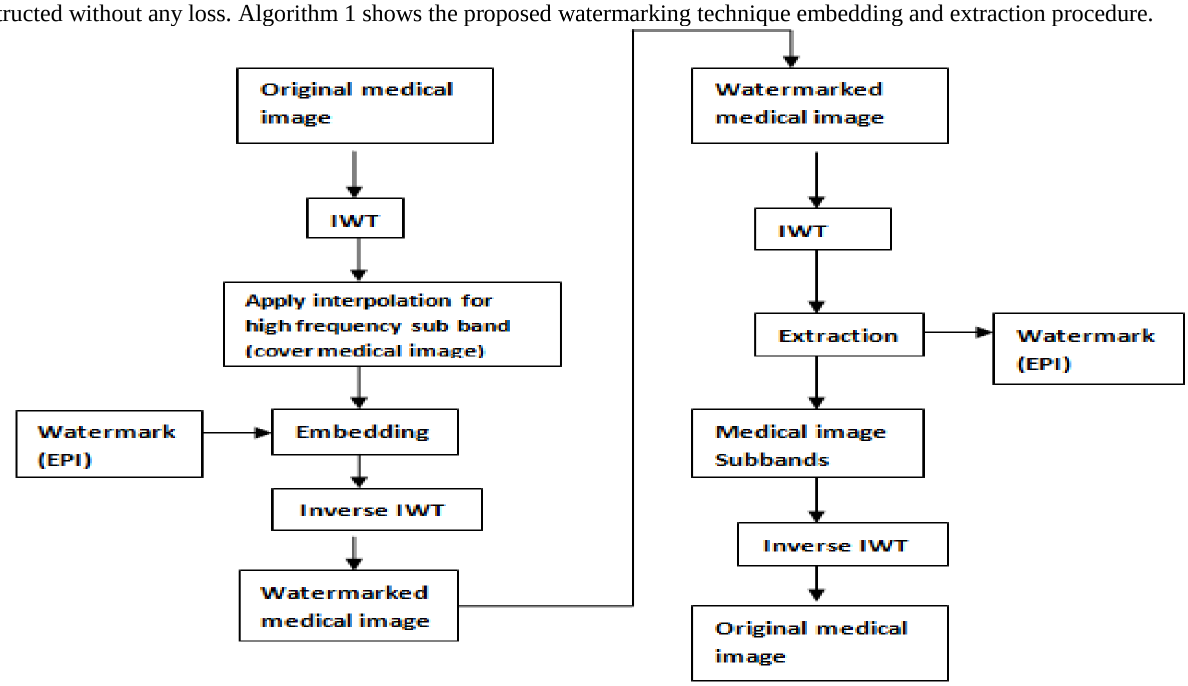

Fig. 1: Proposed watermarking technique

Algorithm 1:
Embedding Phase:
1. Apply IWT to size reduced the original medical image.
2. For low frequency subband apply nearest neighbor interpolation to scale up the image.
3. For high frequency subband apply equations 1-7 to generate a cover image.
4. Embed watermarks (EPI) within an interpolated subband pixel.
5. Apply inverse IWT to generate a watermarked image.

Extraction Phase:
1. Apply IWT to the watermarked image.
2. Repeat the embedding process to extracts the watermark (EPI).
3. Reduce the watermarked image to original medical image size.
4. Apply inverse IWT to reconstruct the original medical image.

3. Experimental Results

The proposed method performance is analyzed using various medical images with the size of 512 X 512 using MATLAB. Figure-2 shows the original medical images. Using the proposed method interpolation, EPI is embedded within the wavelet subbands to generate a watermarked medical image. Figure-3 shows the watermarked images of Figure-2, visually there are no changes in the image quality, at the remote specialist side, watermark (EPI) is extracted and the original medical image is reconstructed.

In order to analyze the proposed method, peak signal to noise ratio (PSNR), mean absolute error value (MAE) and structural similarity index (SSIM) are used. PSNR value is used to evaluate the quality of the watermarked image with the original image. If the PSNR value is high, then the image quality is high. PSNR, MAE and SSIM formulas are specified in equations10-13. I is the original medical image, I' is the watermarked medical image, (i, j) is the pixel positions and m, n is the image row and column size. Using MAE, the pixel loss between the original image and the watermarked image is evaluated. If the value is less then there are no changes in the pixel values. SSIM measures the similarity between the original image and the watermarked image. If the value is equal to 1 then both the images are similar. Table-1 list out the quality measures between the original medical image and image reconstruction.

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right), \tag{10}$$

where MSE is the mean squared error,

$$MSE = \frac{\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\left(I(i,j) - \left(I^{'}(i,j)\right)\right)^2}{mn}. \tag{11}$$

$$MAE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\left|I(i,j) - I'(i,j)\right|, \tag{12}$$

$$SSIM = l(i,j).c(i,j).s(i,j), \tag{13}$$

where l is the luminance, c is the chrominance and s is the structural component.

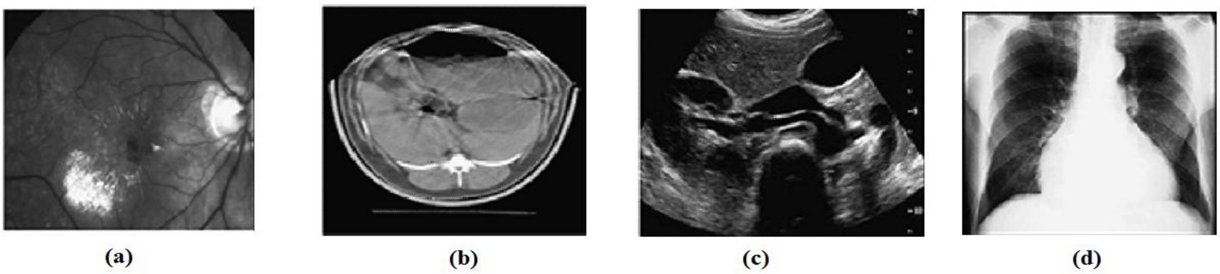

Fig. 2: Original medical images (a) Image1 (b) Image2 (c) Image3 (d) Image4

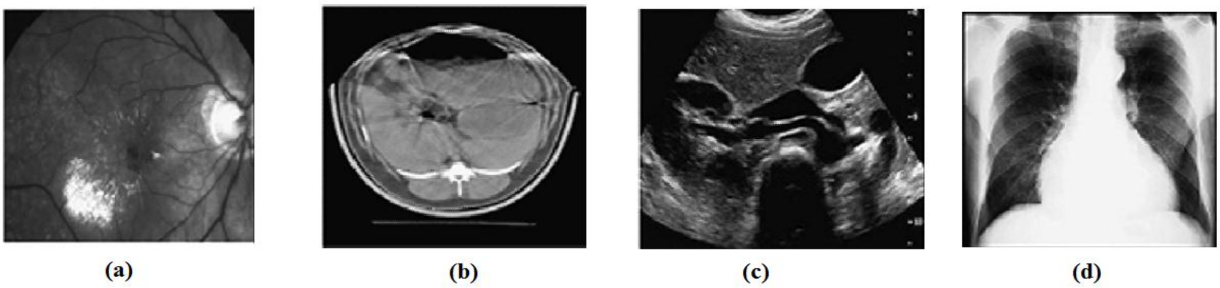

Fig. 3: Watermarked medical images (a) Image1 (b) Image2 (c) Image3 (d) Image4

Table 1: Performance Measures of Proposed Technique

Medical images	PSNR	MAE	SSIM
Image1	48.67	0.0546	0.9453
Image2	47.45	0.0678	0.9346
Image3	48.32	0.0665	0.9417
Image4	48.34	0.0523	0.9541

Table 2: Comparison with the Existing Technique

Medical Images	Proposed method			[8]		
	PSNR	MAE	SSIM	PSNR	MAE	SSIM`
Lena	49.23	0.0837	0.9753	39.23	0.3213	0.8912
Baboon	48.78	0.0863	0.9621	38.17	0.3842	0.8931
Boat	49.05	0.0821	0.9782	38.81	0.3857	0.8943
Airplane	48.64	0.0854	0.9636	38.45	0.3848	0.8939

The proposed method is compared with the existing interpolation technique [8] in table2 for different general images such as Lena, Baboon, Boat and Airplane. The PSNR and SSIM value for the proposed method is high and MAE value is low compare to existing techniques. It shows that the proposed method performs well compare to the existing techniques.

4. Conclusion

A medical image watermarking technique using image interpolation is proposed in this paper. By applying IWT to the original medical image, it is decomposed into four subbands. Using proposed interpolation technique subband size is changed and EPI is embedded. At the remote side, medical images and EPI data are extracted without any loss. PSNR value is high for the proposed method. SSIM value is nearly equal to 1 and MAE value less than 1. The experimental results show that the proposed method transmits the medical data in a secured manner.

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