An Edge Based Blind Watermarking Technique of Medical Images without Devalorizing Diagnostic Parameters

Nilanjan Dey, Prasenjit Maji, Poulami Das, Shouvik Biswas, Achintya Das, Sheli Sinha Chaudhuri

Abstract— **At present most of the hospitals and diagnostic centers globally, have started using wireless media for exchanging biomedical information (Electronic Patient Report or hospital logo) for mutual availability of therapeutic case studies. The required level of security and authenticity for transmitting biomedical information through the internet is quite high. Level of security can be increased; authenticity of the information can be verified by adding ownership data as the watermark in the original information. In our proposed work, watermark is added in the edges, i.e. the boundaries between the Region of Interest (ROI) and the Region of Non-Interest (RONI) in the biomedical image. Our proposed method of adding watermark in the edges of the images is most effectual for those medical images which are resultant of such imaging processes which has edge detection as one of the essential intermediate part of the process. Canny edge based watermarking technique is applied on three different medical images: IVUS image, retinal vascular tree image, CT Scan image and the correlation values of the original watermark image and the extracted watermark image are calculated to show the level of acceptability of the proposed technique. The efficacy of the proposed method claims robustness against most common attacks.**

Keywords – Canny Edge Detection, ROI, RONI, Electronic Patient Report (EPR)

I. INTRODUCTION

In the present mechanized age, globalization has influenced the medical field as well. At present most of the popular diagnostic centers and hospitals globally are practicing exchanges of bio-medical information through wireless media for mutual availability of therapeutic case studies as well as for improvement of diagnostic results.

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Transmission of bio-medical information through the internet requires elevated level security and authenticity. Watermark is added ownership to increase the level of security and to verify authenticity. Patients' information (Electronic Patient Record), logo of the hospitals or diagnostic centers can be added in the bio-medical data as watermark [1, 2] to prove the intellectual property rights [3]. Addition of watermark in a medical signal or image can cause distortion. As all the bio-medical images and signals convey information required in diagnosis of diseases, any kind of distortion is not acceptable. But for authenticity and security of the information a little amount of distortion can be overlooked. So achieving watermarking technique with lesser amount of distortion in bio-medical data is a challenging task.

Different types of bio-medical images such as CT scan, MRI, Ultrasound, IVUS, X-ray images are capable of diagnosing different types of diseases [4, 5, 6, 7, 8]. To detect some diseases like lumen calcification of the artery, diseases related to the retinal vessels, brain tumor, tumors or stones in gall bladder, kidney etc, related bio-medical images requires edge detection as they consist of two types of regions: Region Of Interests (ROI) [9,10] which contain required information to detect diseases and Region Of Non-Interest (RONI) [11] which do not contain necessary information for detecting diseases. In most of the cases, edges of these images are the borders between the ROI and RONI.

In our proposed method, watermark is added within the edges of the images by using blind watermarking technique. Blind Watermarking is a very useful technique to identify ownership and exchange of data in telemedicine. In case of blind watermarking technique, watermark can be extracted without using the original watermark data (EPR or hospital logo) [12]. Blind-Watermarking provides a scope for the authentication of the original information or to provide patient information (Electronic Patient Report). Every watermarking scheme, being able to recover, should provide a way of authenticating the signal. If, in addition, it is possible to determine that a copy has been made leading to some form of data degradation and/or corruption that can be conveyed through an appropriate analysis, then a scheme should be developed that provides a check on: (i) the authenticity of the data n, (ii) its fidelity.

In this paper, proposed method of edge based watermarking is applied in different bio-medical images like IVUS image, retinal vascular tree image, CT scan image. This unique technique of adding watermark in the edges of the images is very effective for those medical images for which edge detection is a vital part of the medical imaging processes. The Proposed method is also tested against some of the most common attacks to prove the robustness of the proposed method.

II. Proposed Method

A. *Watermark Embedding*

Step 1. Gray medical image is converted into binary image.
Step 2. Binary Area Open is used to remove small objects from filtered image.
Step 3. Canny edge detection is applied, followed by dilation and filling regions and holes.
Step 4. Canny edge detection is reapplied on hole filled image.
Step 5. Edge detected image is reshaped into 1D vector.
Step 6. Pixel positions of individual vector elements are stored.
Step 7. Binary watermark image is reshaped into 1D vector.
Step 8. Size of the Binary watermark is calculated.
Step 9. Edge vector is resized based on the size of watermark image vector.
Step 10. All the edge vector values are substituted by watermark binary vector values.
Step 11. All 1s of the watermarked edge vector are converted into 255.
Step 12. Edge vector is complemented.
Step 13. The edge vector elements are restored into their corresponding position in the original gray image.
Step 14. Watermarked sample gray image is generated.

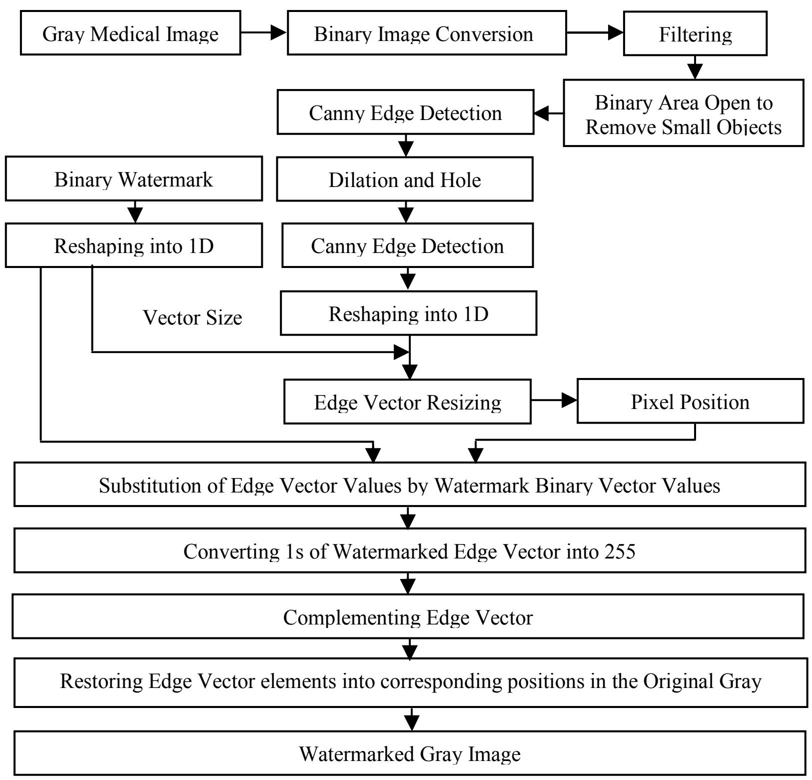


Figure 1. Watermark Embedding

The size of the binary watermarked image is to be sent through the communication channel to the intended receiver along with the watermarked image.

B. *Watermark Extraction*

Step 1. Watermarked grey medical image is converted into binary image.
Step 2. Binary Area Open is used to remove small objects from filtered image.
Step 3. Canny edge detection is applied followed by dilation and Filling regions and holes.
Step 4. Canny edge detection is reapplied on hole filled image.
Step 5. Edge detected image is reshaped into 1D vector.
Step 6. Edge vector is resized based on the size of watermarked image vector.
Step 7. Watermarked Sample grey image is reshaped into 1D vector.
Step 8. The positions of all edge vector elements whose value is 1 are computed.
Step 9. Based on the positions of the edge vector elements corresponding watermarked gray vector pixel values are stored in a separate vector.

Step 10. All (1-255) = -254 values are converted into 0 and all the values greater than 0 is converted into 1, in the resultant vector.

Step 11. Resultant binary vector is reshaped into 2D to generate the recovered watermark image.

Step 12. Correlation values between the watermark and recovered watermarked image is computed.

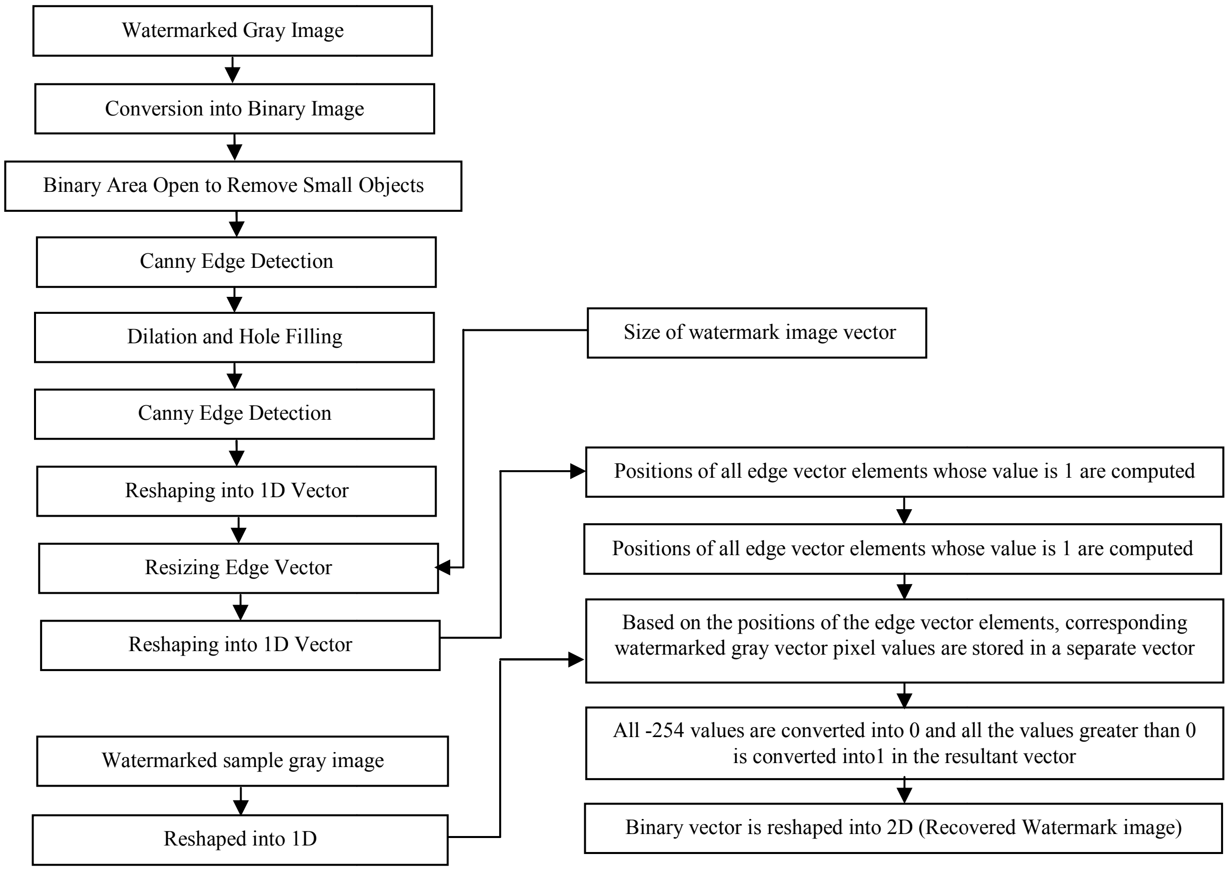
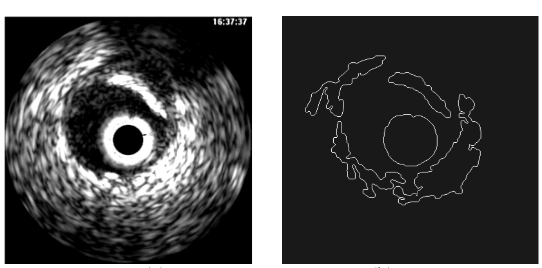


Figure 2. Watermark Extraction

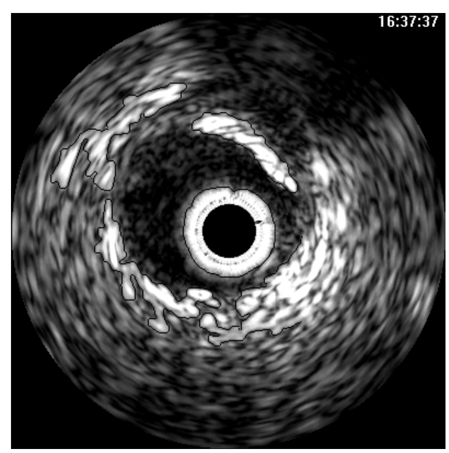
III. RESULT AND DISCUSSIONS

MATLAB 7.0.1 Software is extensively used for the study of visible watermarking. Sample image of IVUS, Retinal Vascular Tree, CT-Scan images are taken under consideration. Concerned images obtained in the result are shown in Fig. 3 to Fig. 5.

A. Watermarking in IVUS



(a) (b)



(c)

(d) (e)

Figure 3. Gray Scale Image, (b) Edge Detcted Image, (c) Watermarked Image, (d) Binary Watermark, (e) Recovered Watermark

B. *Watermarking in Retinal Vascular Tree*

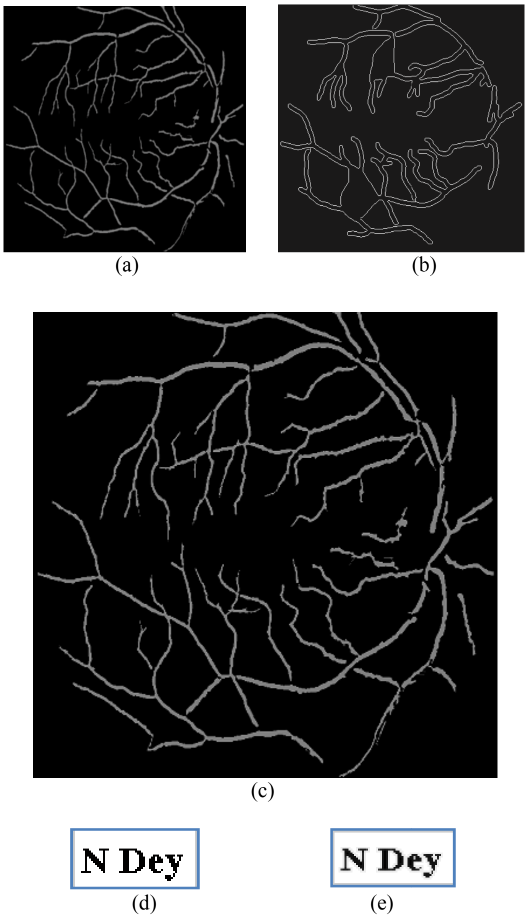


Figure4. (a) Gray Sample Image, (b) Edge detected Image, (c) Watermarked Image, (d) Binary Watermark,(e) Recovered Watermark

C. *Watermarking in CT-Scan*

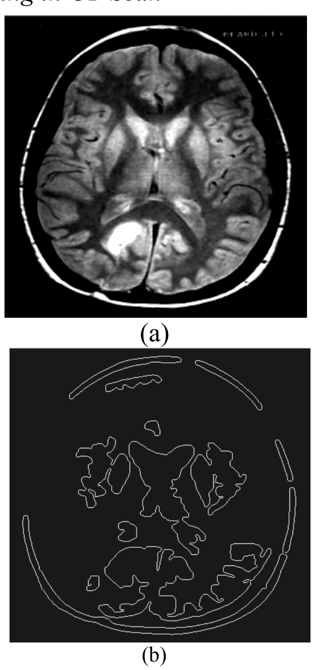


Figure 5. (a) Gray Sample Image, (b) Edge detected image, (c)Watermarked Image, (d)Binary Watermark, (e) Recovered Watermark

D. *Correlation Coefficient*

After secret image embedding process, the similarity of original image x and watermarked image x' is measured by the standard correlation coefficient (c) as follows:

$$C = \frac{\sum_m \sum_n (x_{mn} - x')(y_{mn} - y')}{\sqrt{(\sum_m \sum_n (x_{mn} - x')^2)(\sum_m \sum_n (y_{mn} - y')^2)}} \quad \text{........ (1)}$$

Where y and y' are transforms of x and x'.

TABLE 1.

Sample Image	Correlation of Original Watermark and Recovered Watermark
IVUS Image	**0.7746**
Retinal Vascular Tree Image	**0.9929**
Brain MRI Image	**0.9928**

E. *Peak Signal to Noise Ratio (PSNR)*

It measures the quality of a watermarked image. This performance metric uses to determine perceptual transparency of the watermarked signal with respect to original signal:

$$PSNR = \frac{MN max_{x,y} P_{x,y}^2}{\sum_{x,y} (P_{x,y} - \bar{P}_{x,y})^2} \quad \text{......(2)}$$

Where, M and N are number of rows and columns in the input signal,

$P_{x,y}$ is the original signal and

$\overline{P}_{x,y}$ is the watermarked signal.

PSNR between the original IVUS image and watermarked IVUS image is 28.7862.

TABLE 2. PSNR Table

Original IVUS image vs. Watermarked IVUS image	***PSNR Value***
	28.7862

To investigate the robustness of the proposed method, watermarked image was attacked by salt & pepper noise, image blurring, motion image blurring and speckle noise. The results of these attacks are showing the Table III.

TABLE 3.

IVUS Image	**Correlation**	**PSNR**
Salt & Pepper (Noise Density 0.0009)	0.7257	27.8289
Blurred Image (Disk 1.1)	0.7335	28.7862
Motion Blurred Image (len 0.9, theta 0.9)	0.7335	28.7862
Speckle noise (var 0.0009)	0.4807	28.5410

CONCLUSION

Edge detection plays a vital role in certain fields of medical research. Proposed edge based watermarking technique is advantageous for those medical images, which are generated by the imaging processes having edge detection as one of their major intermediate steps. Information-hiding applications may demand much higher payload capacity. In edge based watermarking technique the payload is remarkably low. The acceptability of the proposed method is due to high correlation value of the original watermark image and the extracted watermark image and also because of embedding without revalorizing the diagnostic parameters of the medical images.

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