An Efficient ICA and DWT Combined Approach for Medical Image Watermarking Technique

S. Siva Kannan, G. Thirugnanam and C. Sheeba Joice

Dept. of EIE, Annamalai University, Chidambaram, India
Dept. of ECE, Saveetha Engineering College, Chennai, India

Abstract: Nowadays medical images or telemedicine’s are transmitted through internet, that want security for various applications. Proposed method is a robust watermarking technique to insert two different watermark image onto the cover image. ROI and RONI are separated from the cover image. We used RONI to insert watermark for exact recovery of watermark. The authors propose a new technique to the blind robust watermarking of medical images. In this approach we develop watermarking algorithm based on ICA and DWT combined approach and insertion of two independent watermarks into medical images (RONI). PSNR value and correlation factor are computed to measure image quality. We designed ICA-DWT algorithm on FPGA and applied to RONI image to insert two individual watermarks. The main advantage of proposed method is ICA-DWT combined approach used for insertion of two individual watermarks.

Key words: Watermarking - Information-Hiding - Authentication - ICA - DWT - FPGA

INTRODUCTION

To overcome the difficulty of change in medical reports and unwanted personal presence by the traditional methods the recent information and communication technologies were introduced. The one area where the medicine, information and telecommunication technology meets is telemedicine, which created a revolutionary impact in health care delivery. Digital mode of managing information is the latest infrastructure for sharing health information. The medical information can be moved, accessed and handled by the way provided by the advanced telemedicine technology, also by its ease of manipulation and replication security could be compromised [1].

Medical image security imposed three important characteristics which are mandatory: Reliability, availability and confidentiality. Reliability internally imposed two aspects: one is authentication, which authenticates that the correct patient gets access on a image provided by a correct source; other one with integrity which protects the images modified by an unauthorized person. The ability of an image to be used by the authenticated person in the normal conditions of access is Availability. Confidentiality is the one which provides access to the image to an entitled person. Security risks during transmission of medical images, random error on images can occur in the network during exchanges within and to other hospital network [2].

The usual watermarking characteristics are common distortions survival, many number of information bits were carried, marks invisibility, secrecy and to insert little computations required. With added additional constraints, these demands exist in medical domain also.

Two main objectives are in the bio medical area

Reversible Watermarking: With the biomedical image qualities medical tradition is very strict. So the method of watermarking must be reversible and from this the exact recovery should have original pixel values. The numbers of possible methods are significantly limited.

Authentication: Particularly in different parts of images from electronic patient record is to be authenticated by a critical requirement in patient record. More often the patient report, which holds the information, identifies an image. An alternative would be to insert all such information into the image itself [3].
In our proposed technique, we introduce an image watermarking algorithm using Independent Component Analysis and Discrete Wavelet Transform (DWT). The cover image is separated into N/2 x M/2 observation images. And then we have applied ICA to all the observation images. Now we have four independent components. Then choose the two components from high frequency level. Selected sub band is wavelet transformed. The two independent watermark information or image is embedded into the corresponding position. Make the whole image Inverse DWT (IDFT) and Inverse ICA transformed and get the cover image and watermark. We have taken patients fingerprint and patient data template as watermark.

**Preliminary:** In this section we will see the region of interest in a medical image, watermarking algorithm using ICA (Independent Component Analysis, DWT and biometric verification method.

**ROI (Region of Interest):** Medical images plays a vital role in obtaining the medical information, as the decision are taken and predicted based on these images. Important part of the medical image is known as Region of interest (ROI). The physician can diagnose in detail with the help of ROI. When there is a slight change in ROI they leads to improper treatments to the patients [4]. Watermarking is done for these images to secure & preserve them and even it is done for the rest of the part of these images called as Region of non interest (RONI). Based on the application of watermarking in these images it is differentiated into two process.

- Extracting ROI from the medical images
- Applying watermarking on RONI

**Independent Component Analysis:** The general ICA based watermarking method includes four stages is shown in Fig. 1.

- The image is split into image patches giving a group of mixed signals. Every patch is then demixed leading to Independent components (IC), employing a preset ICA demixing matrix V, arranged using collection of typical images.
- For each patch, Highest power are selected for watermarking.
- Highest power coefficients are quantized and watermarked. Watermarked and original image difference is denoted by $\Delta$.
- Mixing matrix $A$ is multiplied with $\Delta$ to generate $W$ that is added to the cover image [5].

**Robust Watermarking:** As it is proven that the constituent alongside the highest power denoted as $IC_H$ (approximation of the Original image) is the most robust, the watermark $W$ of the size N/k x M/V is embedded in it [6].

According to the rule,

$$IC_H^W = IC_H + \alpha W$$

$\alpha$ is embedding strength and $IC_H^W$ is watermarked component.

**Discrete Wavelet Transform:** DWT is a transformation algorithm for digital image watermarking in frequency domain. When an image is passed through series of low pass and high pass filters, DWT breaks down the input into sub bands of various energies. Fragmentation is done by disintegrating the input image at various energy levels, Fig. 2 shows 2 level decomposition. We can increase robustness to valid amount by Implanting watermarking in low energy coefficients but most information of the input is intense in LL sub band. Therefore altering it can lead to misinterpretation of input image. So avoid inserting security features in low frequency regions. The regions for watermark insertion are high energy sub bands HL, LH and HH, for human eyes do not respond to modifications in these bands. These frequencies give excellent output without human eye perception. Because frequency sub band HH contains edges and textures of the input it is also left out. Many of the watermarking algorithms are not able to give conceptual perception and robustness in one go since both are contradictory. Remaining choices are HL and LH. Since Human Visual System receptiveness is higher in horizontal region than vertical region, Watermarking is embedded in HL region [7].

**Proposed Method:** Original image is divided into four observation image (N/2 x M/2 images) Then ICA applied to the N/2 x M/2 observation image to get Four individual components. Highest energy components (IC1 & IC2) taken for applying DWT. Then, the horizontal component HL is taken out for inserting the watermark, because embedding the watermark in horizontal regions increases the watermark robustness on image quality.
Watermarking Algorithm Using ICA-DWT: The embedding and extracting procedures are summarized as follows:

- RONI Image is divided into N/2 x M/2 Observation Images
- Apply ICA to all the observation images
- Apply DWT to decompose the Individual components to the required level.
- Select vertical sub band (HL) for embedding.
- The watermark image resized if necessary to make it size the same of selected sub band.
- The value of scaling factor defined to be suitable for invisible watermarking.
- Modify the coefficients of the HL band by adding watermark coefficients:
- Apply IDWT & ICA to obtain the watermarked cover Image, IW.

Separation of Roi: Distortion may occur in ROI, if we use traditional watermarking techniques onto the medical image. Then diagnosis information could be lost. So RONI taken for embedding the watermark onto a cover image. The ROI can be taken out from the cover picture. Excluding ROI, the watermark images are inserted to cover image. Fig. 4 shows selection of ROI in Matlab from the medical image for proper diagnosis by the physician. Fig. 4 shows one of the option for ROI selection in Matlab. Thus, ROI and RONI of images are to be separated before inserting the watermark to a cover image.

Watermarking: RONI image is taken for watermarking. Roni image is divided into N/2 x M/2 observation images. Then the ICA is applied to N/2 x M/2 observation images as shown in Fig. 5.
Fig. 5: IC1 & IC2 are taken for applying dwt to split HH, HL, LH, LL coefficient values

Fig. 6: DWT coefficient of IC1

Fig. 7: DWT Coefficients of IC2

Fig. 8: Finger print watermark is added to HL2 sub band of IC1-DWT (2 level)
Fig. 9: Patient Template watermark is added to HL2 sub band of IC2-DWT(2 level)

**Extraction:** To remove both watermarks first we have to divide the image into \( \frac{N}{2} \times \frac{M}{2}(k^2=4) \) observation images. Then Inverse ICA applied to remove first watermark IC1’ (Inverse of ICA1) is chosen and applied IDWT to extract fingerprint watermark image. Then to remove second watermark IC2’ (Inverse of IC2) is chosen and applied IDWT to extract patient data template watermark image from the original image. To remove both watermarks, watermarked picture is decomposed into \( k^2 = 4 \) observation images which are extracted by ICA and DWT.

**RESULTS AND DISCUSSION**

In this work segmentation portion is implemented in Matlab and ICA-DWT is implemented in FPGA Altera board. We used 512x512 pixel size image cover picture (medical image) and 64x64 pixel finger print and Patient data template as watermark for testing. Perceptual transparency and Robustness are the performance evaluation metrics taken here. Perceptual transparency observed cover image should not be destroyed by insertion of watermark. Measure of quality of processed image is done using PSNR.

<table>
<thead>
<tr>
<th>Watermarked Images</th>
<th>Recovered Watermark</th>
<th>Weighting factor (F), PSNR(db), Correlation(( \rho ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name: JAN</td>
<td>4f23159</td>
<td>F = 0.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PSNR = 49.14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( \rho = 1 )</td>
</tr>
</tbody>
</table>

For robustness inspection of the proposed scheme the watermarked image was tested against several types of attacks namely Salt & Pepper noise, Gaussian noise and Speckle noise. We observe that ICA- DWT based watermarking attains the lowest distortion in the watermarked images in the lack of attacks and better performance for most of the attacks from Table 2.
Table 2: Fig. 5. Performance of the ICA-DWT based watermarking against various types of attacks

<table>
<thead>
<tr>
<th>Attack</th>
<th>Watermarked Image</th>
<th>Extracted Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt &amp; pepper noise</td>
<td><img src="image1" alt="Watermarked Image" /></td>
<td><img src="image2" alt="Extracted Image" /></td>
</tr>
<tr>
<td>Gaussian noise</td>
<td><img src="image3" alt="Watermarked Image" /></td>
<td><img src="image4" alt="Extracted Image" /></td>
</tr>
<tr>
<td>Speckle noise</td>
<td><img src="image5" alt="Watermarked Image" /></td>
<td><img src="image6" alt="Extracted Image" /></td>
</tr>
</tbody>
</table>

Table 3: PSNR Value of ICA-DWT for Different Types of Attack

<table>
<thead>
<tr>
<th>Image Type</th>
<th>ICA-DWT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt &amp; Pepper Noise</td>
<td>47.9064</td>
</tr>
<tr>
<td>Gaussian Noise</td>
<td>48.0123</td>
</tr>
<tr>
<td>Speckle Noise</td>
<td>47.1357</td>
</tr>
</tbody>
</table>

Table 4: FPGA Implementation

<table>
<thead>
<tr>
<th>Architecture</th>
<th>Clock Frequency</th>
<th>Image size of size 512x512 for M9k memory</th>
<th>Overall Throughput(M9k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICA-DWT</td>
<td>350</td>
<td>10</td>
<td>660</td>
</tr>
</tbody>
</table>

**FPGA Implementation:** In order to validate the efficiency of our ICA DWT approach, the fastest folded structure are selected and implemented on altera stratix platform to process 512 x512 size cover image. The storage memory and the numbers of M9 K memory are extracted. For speed performance throughput, that is outlined because the number of images processed per second, is used.

**CONCLUSION**

This paper presents a new technique for embedding two individual watermarks into host image using independent component analysis and discrete wavelet transform. Watermark images are embedded into the ICA transformed vertical sub band of wavelet coefficient. Before embedding, this watermark images has been taken for ICA in order to improve its robustness. By applying this algorithm, the experimental results have demonstrated that the proposed algorithm is imperceptible, because the average PSNR for all test images is 49.14dB. Moreover, the proposed watermarking system is more robust, because it can keep the image quality well.

**REFERENCES**