Contour Extraction & Compression from Watermarked Image using Discrete Wavelet Transform & Ramer Method

Ali Ukasha, Majdi Elbireki, and Mohammad Abdullah

Abstract—In this paper we have implemented a digital watermarking technique based on single level discrete wavelet transform (DWT). The technique a watermark bits embedded into the selected high-pass filter coefficients of a cover image by using zonal sampling methods. This scheme requires side information (high pass filter coefficients) in watermark recovery. Experimental results show that the watermark is robust to geometric attacks (Gaussian noise is used in this paper). The contours of the original image can be extracted easily by using of SSPCE (single step parallel contour extraction) method from blurred watermarked image. To compare the results, the mean square error, signal-to-noise ratio criterions, and compression ratio (or bit per pixel) were used. Experimental results for contour extraction and compression provide the comparative results in between these algorithms in terms of normalized correlation (NC). The simplicity of the method with accepted level of the reconstruction is the main advantage of the proposed algorithm.

Keywords—Digital watermarking, DWT transform, contour extraction, Ramer algorithm

I. INTRODUCTION

In the recent years, a huge amount of digital information is circuiting through all over the world by means of the World-Wide Web. Most of this data is exposed and can be easily forged or corrupted. The need for intellectual property rights protection arises. Digital watermarking has been proposed as one of the possible ways to deal with this problem, to keep information safe. The watermarking of digital data has become very popular approach for intellectual property rights protection arises. Digital watermarking is becoming popular, especially for adding undetectable identifying marks, such as author or copyright information. Because of this use, watermarking techniques are often evaluated based on their invisibility, recoverability, and robustness. It is often desired to retrieve the embedded information without reference to the host data; this is known as blind watermarking [8]. Our goal was to implement watermarking method and evaluate their susceptibility to attack by various image processing techniques. The simulation is done using Matlab programming to add and extract watermarks.

The watermark embedding was performed in the transform domain. According to the proposed model, in the discrete wavelet largest coefficients was replaced by the linear combination of the watermark. The quality of the resulted watermarked images was measured and analyzed before and after blurred by Gaussian. Recommendations for the embedding system were stated. Watermark robustness against blurred image by Gaussian attacks was verified. Number of detection experiments with accordance to embedding parameters was made. The spectrum image (high-pass filter coefficients) was considered as a possible way to detect embedded watermark. For binary image obtained the suitable parameters was made. The spectrum image (high-pass filter coefficients) was considered as a possible way to detect embedded watermark. For binary image obtained the suitable threshold is applied to the blurred watermarked image. Then the contours extraction are detection using single step parallel contour extraction (SSPCE) method [9], [10].
II. DISCRETE WAVELET TRANSFORM

To solve difficult problems of physics, computers, and mathematics, wavelet transform is used. It allows difficult problems to be decomposed into elementary form and then reconstructed with high precision. DWT provides various applications like compression, image processing, signal processing, etc [11], [12]. Wavelet transforms are based on small wavelets with limited duration (this paper uses Haar). The forward and inverse DWT are defined in equation (1) & equation (2) respectively.

\[
 a_{jk} = \sum f(t)\psi_{j,k}(t) \tag{1}
\]

\[
f(t) = \sum a_{jk}\psi_{j,k}(t) \tag{2}
\]

Where \( \psi_{j,k}(t) = 2^{j/2}\psi(2^j t - k) \)

Two dimensional wavelet transform can be considered as an extension of 1D wavelet transform. DWT’s are particularly effective in analyzing waveforms which have spikes or pulses buried in noise. 2D- signals such as images can be decomposed using many wavelet decomposition filters in many ways (we use Haar wavelet filter).

III. ZONAL SAMPLING METHODS

A lot of zonal sampling methods which was described in [13], shows that the best scheme for compression and contour extraction is as illustrated in Fig. 1. Fit criterion of the algorithm consists in selecting one of the squared block of the spectral images (e.g. shadow region) as LPF filter for image compression and the other coefficients will be taken into account in the contour reconstruction stage as shown in the Fig. 2. This algorithm in this work is referred as algorithm I [13], [14].

IV. DESCRIPTION OF THE ALGORITHM

The forward single level DWT transform is applied to the gray-level image. By using low and high-pass filters after the zonal procedures (algorithms I & II) the two spectral sub-images are obtained for each sub images. The HPF coefficients for details coefficients are used to embedding process. The digital watermark is the embedded to the N largest values in HPF details sub-images coefficients using the following equation

\[
 \text{New} _\text{coefficient} = (\text{Coefficient} _\text{of} \text{HPF})^{\ast}(1 + aW) \tag{3}
\]

Where \( a \) is parameter determined the coefficient value and the \( W \) is watermark bits.

The inverse wavelet transform is taken to the combined low and high pass filters images. Then the watermarked image is attacked geometrically. The SSPCE (single step parallel contour extraction) method is applied to the binary image which is obtained by suitable threshold value applied to the noisy digital watermarked image.

Flowchart of the proposed embedded digital watermark & contour extraction and compression is depicted in Fig. 3.

The extraction step of watermark from host image is similar to the process of the embedded algorithm. The watermarked image must be transformed to frequency domain by DWT approach. The N largest coefficients of the spectral image (HPF) are determined. The inverse wavelet transform is applied to extract the watermark using the formula

\[
 X = \frac{\text{Coefficient} _\text{of} \text{HPF(Watermarked Image)}}{\text{Coefficient} _\text{of} \text{HPF(Original)}} - 1) / \alpha \tag{4}
\]

Where \( \alpha \) is extracted watermark bits.

Flowchart of the digital watermark extraction is depicted in Fig. 4.

The analyzed algorithms use method of contour extraction called (SSPCE) with 3x3 pixels window structure. By using the central pixel the object contours is extracted and the all possible edge direction is found which connects the central pixel with one of the remaining pixels surrounding it [9], [10].
As a further test, the Tools image was geometrically attacked by the Gaussian. A zero-mean Gaussian noise with standard deviation 11 was used. Though the image degradation is so heavy that it cannot be accepted in practical applications, the mark is still easily recovered.

V. RAMER METHOD FOR CONTOUR COMPRESSION

Ramer presented an iterative method which starts with an initial segmentation and splits the segment at the point which has the farthest distance from the corresponding segment unless the approximation error is no more than the pre-specified tolerance [15]. The vertices of an edge of the approximating polygon are determined by these stored points.

VI. APPLIED MEASURES

To evaluate the image & contour compression ability, the following equations (5) & (6) for bit per pixel & compression ratio are used respectively.

\[ hpp = \frac{S \times 8}{(n \times m)} \]  \hspace{1cm} (5)

\[ CR = \left( \frac{L_{CC} - L_{AC}}{L_{CC}} \right) \times 100\% \]  \hspace{1cm} (6)

Where: \( S \) is Coefficients number in the desired zonal used as LPF filter; \( n \times m \) is size of the image; \( L_{CC} \) is original contour length and \( L_{AC} \) is approximating contour length.

The mean square error (MSE) and peak signal-to-noise ratio (PSNR) criterions were used to evaluate the distortion introduced during the image reconstruction and contour compression procedures. The MSE & PSNR criterion are defined by the equations (7) & (8) respectively.

\[ MSE(I, \tilde{I}) = \frac{1}{(n \times m)} \sum_{i=0}^{n} \sum_{j=0}^{m} (I(i,j) - \tilde{I}(i,j))^2 \]  \hspace{1cm} (7)

\[ PSNR(I, \tilde{I}) = 10 \log_{10} \left( \frac{(L-1)^2}{MSE(I, \tilde{I})} \right) \]  \hspace{1cm} (8)

where is the grey-level number.

VII. RESULTS OF THE EXPERIMENTS

To visualize the experimental results a tools image & digital watermark image are selected. Selected images are shown in Figure 5. Text of digital watermark means "SebhaUniversity" in Arabic language. To obtain blurred watermarked image we create a point-spread function, PSF, corresponding to the linear motion across some pixels (LEN), at an angle of certain degrees (THETA). Images results of blurred watermarked, extracted digital watermark and contour compression using Ramer method by using of algorithms I & II zonal sampling are shown in Fig. 6 to Fig. 9 (related results are shown in Tables I to IV).

![Fig. 5 Test images: a) Host (Tools), and b) Watermark](image-url)
TABLE I
BLURRED WATERMARKED & EXTRACTED DIGITAL WATERMARK IMAGES USING ALGORITHM I (N=M=66): BIT PER PIXEL = 0.2697

<table>
<thead>
<tr>
<th>Measures</th>
<th>LEN</th>
<th>THETA</th>
<th>Autocorrelation</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>11</td>
<td>5</td>
<td>0.9843</td>
</tr>
<tr>
<td>b)</td>
<td>13</td>
<td>7</td>
<td>0.8962</td>
</tr>
<tr>
<td>c)</td>
<td>41</td>
<td>18</td>
<td>0.7206</td>
</tr>
<tr>
<td>d)</td>
<td>21</td>
<td>11</td>
<td>0.6851</td>
</tr>
</tbody>
</table>

Fig. 6. Results of extracted digital watermark algorithm I of zonal sampling

TABLE II
CONTOUR COMPRESSION USING RAMER METHOD & ZONAL SAMPLING (ALGORITHMS I) Method

<table>
<thead>
<tr>
<th>Measures</th>
<th>LEN</th>
<th>THETA</th>
<th>MSE</th>
<th>PSNR [db]</th>
<th>CR [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 0.1</td>
<td></td>
<td></td>
<td>0.0000</td>
<td>Inf</td>
<td>58.2377</td>
</tr>
<tr>
<td>b) 0.8</td>
<td></td>
<td></td>
<td>0.0559</td>
<td>48.9373</td>
<td>78.5107</td>
</tr>
<tr>
<td>c) 1.2</td>
<td></td>
<td></td>
<td>0.1321</td>
<td>44.8564</td>
<td>82.5763</td>
</tr>
</tbody>
</table>

Fig. 7. Results of contours compression images using algorithm I (N=M=66)

TABLE III
BLURRED WATERMARKED & EXTRACTED DIGITAL WATERMARK IMAGES USING ALGORITHM II (N=M=47): BIT PER PIXEL = 0.2699;

<table>
<thead>
<tr>
<th>Measures</th>
<th>LEN</th>
<th>THETA</th>
<th>Autocorrelation</th>
</tr>
</thead>
<tbody>
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<tr>
<td>b)</td>
<td>13</td>
<td>7</td>
<td>0.9618</td>
</tr>
<tr>
<td>c)</td>
<td>41</td>
<td>18</td>
<td>0.8066</td>
</tr>
<tr>
<td>d)</td>
<td>21</td>
<td>11</td>
<td>0.7529</td>
</tr>
</tbody>
</table>
**Fig. 8. Results of extracted digital watermark algorithm II of zonal sampling**

**TABLE IV**

<table>
<thead>
<tr>
<th>Measures</th>
<th>MSE</th>
<th>PSNR [db]</th>
<th>CR [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 0.1</td>
<td>0.0000</td>
<td>64.5605</td>
<td>58.3937</td>
</tr>
<tr>
<td>b) 0.83</td>
<td>0.0588</td>
<td>49.1027</td>
<td>78.5300</td>
</tr>
<tr>
<td>c) 1.115</td>
<td>0.1204</td>
<td>45.8304</td>
<td>82.6748</td>
</tr>
</tbody>
</table>

**Fig. 9. Results of contours compression images using algorithm II (N=M=47)**

**VIII. CONCLUSION**

New technique for contour compression (Ramer method used in this work) from blurred watermarked image is presented. By using single level of wavelet transform the digital watermark is embedded in selected high pass filter coefficients of detailed sub-images using zonal sampling methods. The results show that this kind of algorithms has a satisfactory performance under image blurred by Gaussian noise. The extracted contours are obtained from blurred digital watermarked image using SSPCE contour extraction method. Simulation results using MATLAB programming show that using both algorithm of zonal sampling method the digital watermark can be extracted with normalized autocorrelation greater than 0.7. However using second algorithm of zonal sampling method the compression ratio of contours can be improved by about 0.9 decibels.

**REFERENCES**


