Novel digital image watermarking using Sobel Filter

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Abstract
Using filters in digital image watermarking makes improvement in the criterion of the watermarking. Watermarking in the edges of the images by using the filters such as Sobel filter operates much more improvements in the imperceptibility of the watermarking rather than not using the edge detection embedding. In this paper, the fact that Human Visual System (HVS) is less sensitive to distortion around edges and textured areas of the image compared to distortion in smooth area is exploited. This paper is presented the novel non-blind watermarking by using the Sobel filter in the Discrete Cosine Transform (DCT) domain. Because of existence of noise near edges of images in the Discrete Wavelet Transform (DWT) the results show that embedding in the DCT domain has better imperceptibility rather than DWT domain.

Key words: Discrete Cosine Transform, Edge detection, Sobel filter, Watermarking, Non-blind.

1. Introduction
Digital data on the insecure channels as Internet are faced with the problem of securing the digital data. This issue is a major justification to present a research activity in the area of digital watermarking. Watermarking is one of the ways of the resistance images from the malicious or unintentionally attacks for removing the authentication of the digital data such as images, videos, sounds or even texts in the insecure channels as Internet. In digital image watermarking the message hides inside the cover image without attracting the attention of third party and the main goal of that is to protect message so that eavesdropper cannot remove or replace the message hidden in the cover image, Malakooti and Khedrzaadeh (2012). A digital watermark is a code carrying information about the copyright owner, the creator of the
work, the authorized consumer and whatever is needed to handle the property rights associated to any given piece of information, Malakooti and Khedrzadeh (2012). During these days using watermarking is known as an effective way for sending the digital data. Watermarking is divided into two main Domains: Spatial domain and transform domain, Barni et al. (1998). Transform domain has much attraction rather than spatial domain recently. Transform domain based on the transform function divided in several kinds of watermarking in the transform domain. The most used transformed functions can be categorized into these categories: Discrete Fourier Transform\(^1\), Discrete Cosine Transform\(^2\) and Discrete Wavelet Transform\(^3\), Piva et al. (1997).

Transform domain method has the following advantages: 1) the embedded watermark signal energy can be distributed to all the pixels of the airspace, help ensure the watermark invisibility; 2) certain characteristics (such as frequency masking characteristics) of the visual system (HVS) may be more easily coupled to the watermark encoding process; 3) the frequency domain method is compatible with international data compression standard, in order to achieve in the compressed domain (compressed domain) within watermark encoding. DCT and DWT have higher speed manipulation in the watermarking rather than the DFT. In comparison of DCT and DWT both of them have such qualities which are separated for the usage of them in watermarking. For instance results show that for having high resistance to the Gaussian noise DCT is preferred. As Singh et al. (2012) claimed there is noise near edges of images after transforming the image into the DWT.

This paper is organized into three parts. In the first part the Sobel filter is introduced and in the second part the watermarking algorithm which is used here is presented. At the end the results are shown and the future work is mentioned to improve the results of this watermarking algorithm.

2. Sobel filter

Sobel filtering is a three step process. Two 3*3 filters (often called kernels) are applied separately and independently, Kumar and Sailaja (2011). The weights these kernels apply to pixels in the 3*3 region are depicted in Fig 1.

\[
\begin{array}{|c|c|c|}
\hline
-1 & 0 & +1 \\
\hline
-2 & 0 & +2 \\
\hline
-1 & 0 & +1 \\
\hline
\end{array}
\quad
\begin{array}{|c|c|c|}
\hline
+1 & +2 & +1 \\
\hline
0 & 0 & 0 \\
\hline
-1 & -2 & -1 \\
\hline
\end{array}
\]

Fig 1. Kernel of Sobel filter

\(^1\) DFT
\(^2\) DCT
\(^3\) DWT
The idea behind these two filters is to approximate the derivatives in x and y, respectively. The results of these two filters $G_x(x,y)$ and $G_y(x,y)$. The Sobel filter approximates the gradient magnitude based on the partial derivatives $(G_x(x,y) \text{ and } G_y(x,y))$ from the previous steps, Bedi et al. (2009). The gradient magnitude, which is the result of the Sobel filter $S(x,y)$, is shown in Eq. 1.

$$S(x,y) = \sqrt{(G_x(x,y))^2 + (G_y(x,y))^2}$$ (1)

The gradient's direction can be calculated by Eq. 2.

$$\theta = \arctan2(G_x + G_y)$$ (2)

3. Proposed watermarking algorithm

Let $I$ be the original gray-level image of size $N_1 \times N_2$ and the digital watermark $W$ be a Gaussian noise. Then each block of $I$ will be transformed into DCT independently by Eq. 3.

$$I_{\text{DCT}} = \text{DCT2}(I)$$ (3)

The edge detector function is used to find the edges of the cover image, Agarwal and Goyal (2007). The Sobel or Prewitt operator has the best answer to find the edges of the image $(I_{\text{edge}})$. Then threshold $T_1$ is selected for watermarking and extraction the watermark and also two alphas value are selected for watermarking. The summation of each block of edges is computed. The block diagram of watermarking algorithm is shown in the Error! Reference source not found.

![Fig 2. Block diagram of watermarking by using edge detection](image)

If the summation of one block in the cover image $(T_1)$ was bigger than threshold, which was selected before $(T)$, the Alpha will be equal to Alpha1 and if not Alpha will be equal to Alpha2. The embedding equation is presented in Eq. 4.
block_emb = block_DCT * (1 + Alpha * Mark (k)) \hspace{1cm} (4)

Where block_emb is the watermarked block of cover image and block_DCT is the cover image blocks. Alpha can be alpha1 or alpha2. It depends on the summation of blocks. Mark (k) is the watermark values. After embedding, the watermark embeds into the cover image by \((4)\). Then IDCT\(^4\) is performed to the watermarked image to get back the watermarked image into spatial domain. The objective evaluation of image quality is performed by the PSNR\(^5\) and BER\(^6\) which is defined as Eq. 5~7.

\[
\text{PSNR} = 10 \log_{10} \left( \frac{M_1 \times M_2}{\text{MSE}} \right) \hspace{1cm} (5)
\]

Where MSE is the mean square error:

\[
\text{MSE} = \frac{1}{MN} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} [x(i,j) - y(i,j)]^2 \hspace{1cm} (6)
\]

\[
\text{BER} = \frac{\sum_{i=1}^{N} w_i \oplus w_i'}{N} \hspace{1cm} (7)
\]

Where \(M_1\) and \(M_2\) are the size of image (row of numbers and column of the numbers), \(x(i,j)\) and \(y(i,j)\) are the pixels of the original image and watermarked image respectively. \(N\) is the bit number of the watermark, and \(W_i\) and \(W_i'\) are the original watermark bits and extracted watermark bits respectively. \(\oplus\) is Xor operation between two binary numbers. A larger PSNR indicates that the watermarked image more closely resemble the cover image, meaning that the watermarking methods makes the watermark more imperceptible. Also a lower BER suggests that the extracted watermark resembles the original watermark more closely.

The extraction process is the same way of embedding. Firstly, the edge of cover image is obtained by using the Sobel filter. Then it is subtracted from the watermarked image and by using the known threshold \((T_1)\) the watermark is obtained. Therefore the algorithm is non-blind embedding which means for extracting the watermark the cover image is needed.

4. Experimental results

\(^4\) Inverse Discrete Cosine Transform \(^5\) Peak Signal to Noise Ratio \(^6\) Bit Error Rate
This section represents the simulation part using the titled DCT and edge detection technique. The images used to calculate the PSNR, BER are Lena and Cameraman images. Fig.1 (a) and 1(b) show the random watermark and cover image of size 512*512 and 64*64, respectively. The experiments of applying external attacks are demonstrated in Table 1 to evaluate the performance of the proposed scheme with the Kumar & Sailaja (2011) algorithm. The results show that the proposed algorithm has much more robustness and imperceptibility against most of the famous attacks rather than their algorithm. That is because of changing the transform domain into DCT domain which has less noise around the edges in comparison with DWT domain. The watermarked image and extracted watermark for is shown in Fig 5.
Table 1. Proposed algorithm and Kumar & Salija algorithm Comparison.

<table>
<thead>
<tr>
<th>Images</th>
<th>Proposed Algorithm</th>
<th>Kumar &amp; Sailaja algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PSNR</td>
<td>BER</td>
</tr>
<tr>
<td>Lena</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Attack</td>
<td>45.18</td>
<td>0.31</td>
</tr>
<tr>
<td>Salt &amp; Pepper noise</td>
<td>31.12</td>
<td>0.58</td>
</tr>
<tr>
<td>Histogram Equalization</td>
<td>29.67</td>
<td>0.62</td>
</tr>
<tr>
<td>Cameraman</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Attack</td>
<td>48.37</td>
<td>0.28</td>
</tr>
<tr>
<td>Salt &amp; Pepper noise</td>
<td>33.17</td>
<td>0.67</td>
</tr>
<tr>
<td>Histogram Equalization</td>
<td>31.40</td>
<td>0.73</td>
</tr>
</tbody>
</table>

5. Conclusions
In this paper, a novel non-blind image watermarking has been presented. Because of existence of noise near edges of images, the DCT is used here to avoid the unwanted noise around the edges. The Sobel edge detection in the DCT domain is used to embed the watermarks. From experimental results, it can be concluded that the watermarked image has good results in invisibility criterion.

References


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