A ROBUST METHOD FOR DIGITAL IMAGES WATERMARKING BASED ON COMBINATION OF SVD, DWT AND DCT USING OPTIMAL BLOCK

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ABSTRACT

With the growth of the Internet, development of digital media technologies and computer network, the change and the protection of copyright have become very important. To protect multimedia data against illegal recording and retransmission, the integration of a signal (digital signature, watermark) has become an obligation without modifying quality of the original image, the goal of this operation is to identify the owner and protect his intellectual property. Digital watermarking has been proposed as a solution to solving the copyright problem by introducing invisible data (watermark) into original image. In this paper, we propose a robust method for digital images watermarking. This method is achieved by searching the optimal block that can be used to insert the watermark in original image by modifying the singular value decomposition (SVD) in DWT (discrete wavelet transform) combined with DCT (Discrete Cosine Transform). The experimental results show that this imperceptible method combines the advantage of three transformations to ensure robustness against most attacks.

Keywords: Watermarking, DWT, SVD, DCT, Entropy

1. INTRODUCTION

The World Wide Web has evolved significantly in different areas, especially multimedia technologies, involving extensive use of digital data such as images and videos. The information that vehicle in this world is a large database that requires an efficient way to meet the intellectual property [1-2]; this condition has become an important factor in the emergence of this technology. The digital image watermarking has been a reliable way to ensure that intellectual property [3-4]. Digital watermarking has many applications in several areas, such as the application of copyright protection, authentication, and secret communication [5]. Digital image watermarking means a discipline of applied mathematics that studies the digital images and their transformations in order to improve their quality or to extract information [6-7]. This discipline involves inserting an invisible mark (digital signature) in an image or other digital documents. The inserted mark must be known by the owner or the distributor, and it must meet three basic requirements: imperceptibility, robustness and capacity [8-9]. Imperceptibility means that the deformation of the image must be low enough that the user cannot distinguish the difference between the watermarked image and the original image [10]. The robustness is the power to recover the inserted even if the watermarked image was manipulated by attacks [11]. Capacity of the watermarking system is defined as the maximum amount of information that can be embedded in the original image [12]. These constraints must come together to create a scheme of a system for watermarking images that can be described insertion and extraction of the mark. This scheme should be have a good robustness against conventional and geometrical attacks [13].

![Figure 1: standard watermarking scheme](image-url)
In this study we present a robust method of watermarking based on optimal block selected by the level value of entropy [14,15], then we make modification in singular value decomposition (SVD) of this bloc after the application of DWT combined with DCT, to ensure the robustness and imperceptibility of our watermarking scheme.

This paper will be organized as follows. Section 2 illustrates the decomposition techniques of images processing. Section 3 presents the proposed method watermarking scheme in detail. Section 4 clarifies experiment results as well as some discussions. Conclusions are given in section 5.

2. DECOMPOSITION TECHNIQUES OF IMAGES PROCESSING

We know that the goal of watermarking is insertion of secret information that will be difficult to extract, for this we will need to insert in specific parts of the image. To find these parts there are various techniques of decomposition [16] and transformation as DCT, DWT, SVD, so on.

2.1 Discrete Cosine Transform

DCT is a transformation function used in signal processing. It transforms a signal from the spatial domain to the frequency domain. Its performance allows it to be used in the JPEG standard for image compression. DCT is been applied in many areas such as data compression, pattern recognition image processing and so on [17, 18]. The DCT and its inverse manner can be expressed as follows:

$$DCT(i,j) = \frac{1}{\sqrt{2N}} B(j) B(i) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} M(x,y) \cos \left[ \frac{(2x+1)i\pi}{2N} \right] \cos \left[ \frac{(2y+1)j\pi}{2N} \right]$$

Where

$$B(u) = \begin{cases} \frac{1}{\sqrt{2}} & \text{if} \ (u = 0) \\ 1 & \text{if} \ (u > 0) \end{cases}$$

The corresponding inverse transformation (Whether 2D IDCT) is defined as:

$$M(x,y) = \frac{1}{\sqrt{2N}} B(i) B(j) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} DCT(i,j)$$

2.2 Discrete Wavelet Transform

DWT is a method for analyzing multi-level signal [19, 20]; it can analyze the signal at different frequency bands with different resolutions by decomposing it into approximation and detailed information. The principle of the algorithm is to divide the image into four at each iteration, three blocks on the details of the image (LH, HL, HH), and the fourth (LL) corresponds to the most important information for the eye (low frequencies), which serves basis for the next iteration [21, 22]. To decompose this image into sub image we use: high and low pass filters.

![Figure2: Discrete Wavelet Transform](image)
2.3 SVD based watermarking

Singular value decomposition (SVD) is a numerical analysis tool used to diagonalize matrices. It is developed for a variety of applications algorithm. The main properties of the SVD in terms of image processing applications are: Singular values (SVs) of the image have very good stability to know when a small perturbation is made in the image of the SV does not change significantly; SV is an algebraic intrinsic property. SVD processing in a matrix A can be decomposed into three matrices of the same size as the initial matrix; two orthogonal matrices U and V and a diagonal matrix S [23].

\[ A = U * S * VT \]

The columns of U and V are called respectively left and right singular vectors of A. They essentially determine the details geometry of the original image. The diagonal values of the matrix S are ranked in descending order. [24]

\[ \sigma_1 \geq \sigma_2 \geq \sigma_3 \geq \ldots \ldots \sigma_r \geq \sigma_{r+1} \geq \ldots \ldots \sigma_n = 0 \]

2.4 Entropy

Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image. Entropy is defined as:

\[ H = -\text{sum}(p.*\log2(p)) \]

Where p contains the histogram counts returned from imhist. By default, entropy uses two bins for logical arrays and 256 bins for uint8, uint16, or double arrays. [25]

3. PROPOSED METHOD

The proposed algorithm combines the properties of DWT, DCT and SVD techniques to increase the robustness and capacity of the algorithm by selecting specifics blocks which have the maximum entropy value. The procedure for embedding the watermark is given below.

3.1 Watermark embedding process

The embedding process is divided into following steps and is briefly described as given bellow:

Step 1: apply DWT on the original image to decompose it into 64x46 sub-bands LL2, LH2, HL2, and HH2.

Step 2: devising image into different blocks (sub-images) and calculate the entropy of each block. After we select the block which has the maximum entropy from LH and HH sub-bands, then we applied DCT to it and get DCT coefficient matrix A and D.

Step 3: apply SVD to A and D.

\[ A = U_a * S_a * V^T; \]
\[ D = U_d * S_d * V^T. \]

Step 4: apply DWT on the watermark image.

Step 5: apply SVD to HH sub band to get B matrix,

\[ B_w = U_w * S_w * V^T. \]

Step 6: modify S_a with watermark such that

\[ S_2 = S_a + \alpha S_w. \]

Step 7: modify S_d with watermark such that

\[ S_2 = S_d + \alpha S_w; \]

Step 8: obtain A*, A* = U_a * S_2 * V^T.

Step 9: Apply inverse DCT to obtain LH* and HH*.

Step 10: Apply inverse DWT to LL, LH*, HL, HH*.

Step 11: obtain the watermarked image.

These steps are described with this scheme.
3. EXPERIMENTAL RESULTS

The robustness is tested under 9 types of attacks: Salt and pepper, Gaussian noise, median filtering, resizing, contrast adjustment, JPEG compression, cropping, and rotation, Histogram equalization. The watermarked image and Extracted Watermark with and without attacks are shown in Figure 5 and 6.

The original image considered for the experimentation is 512 x 512 Lena. The watermark image is of 32 x 32 sizes which is a logo as shown in Figure 4. Figure 5 indicates that visual appearance of the watermarked image is good with a PSNR of 58.049 dB. The metrics used to assess the performance of the proposed algorithm are PSNR and NC (between original and watermarked image to improve the imperceptibility).

Normalized Correlation Coefficient is defined as follows:

\[
NC = \frac{\sum_{i=0}^{M} \sum_{j=0}^{N} OW \cdot EW}{(\sum_{i=0}^{M} \sum_{j=0}^{N} OW \cdot OW)}
\]

PSNR (peak to signal-to-noise ratio) is defined as follows:

\[
PSNR = 10 \log_{10} \left( \frac{255^2}{MSE} \right)
\]

The results of different attacks are given as bellow:
Salt and pepper noise (0.01 density)

PSNR = 25.1990 dB
NC = 1

Resizing

PSNR = 12.5311 dB
NC = 0.9107

Rotation (20°)

PSNR = 11.2633 dB
NC = 1

Contrast adjustment

PSNR = 20.4928 dB
NC = 1

Gaussian noise

PSNR = 19.7690 dB
NC = 1

Cropping 25%

PSNR = 12.5989 dB
NC = 1

Median filtering (3x3) kernel

PSNR = 25.5455 dB
NC = 0.9896

JPEG QF = 70

PSNR = 29.4579 dB
NC = 0.9999
PSNR=28.4359 dB
NC=1

Histogram equalization

Figure 6(a). Attacked watermarked image with PSNR and NC.
(b). Extracted watermark from LH matrix.
(c). Extracted watermark from HH1 matrix.

These results are resumed in table and graphs as bellow:

<table>
<thead>
<tr>
<th>Attacks</th>
<th>PSNR</th>
<th>NC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without attack</td>
<td>58.049</td>
<td>1</td>
</tr>
<tr>
<td>Salt and pepper noise (0.01 density)</td>
<td>25.1990</td>
<td>1</td>
</tr>
<tr>
<td>Rotation (20°)</td>
<td>11.2633</td>
<td>1</td>
</tr>
<tr>
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<td>0.9107</td>
</tr>
<tr>
<td>Contrast ajustement</td>
<td>20.4928</td>
<td>1</td>
</tr>
<tr>
<td>Cropping 25%</td>
<td>12.5989</td>
<td>1</td>
</tr>
<tr>
<td>Histogram equalization</td>
<td>28.4358</td>
<td>1</td>
</tr>
<tr>
<td>JPEG QF~70</td>
<td>29.4579</td>
<td>0.9999</td>
</tr>
</tbody>
</table>

4. CONCLUSION

In this paper a robust watermarking method for copyright protection has been proposed. This method based on combination of three transformations DCT, DWT, SVD using optimal block ensure the criteria of digital image watermarking, robustness, imperceptibility and capacity. The experimental results show that this method is robust against most attacks. Thereby we can conclude that intellectual property of images is protected by our approach.

REFERENCES:


