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Enhancement of Genetic Image Watermarking Robust Against Cropping Attack

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ABSTRACT

The enhancement of image watermarking algorithm robust against particular attack by using genetic algorithm is presented here. There is a trade-off between imperceptibility and robustness in image watermarking. To preserve both of these characteristics in digital image watermarking in a logical value, the genetic algorithm is used. Some factors were introduced for providing robustness of image watermarking against cropping attack such as the Centre of Interest Proximity Factor (CIPF), the Complexity Factor (CF) and the Priority Coefficient (PC).

KEYWORDS

Cropping, Genetic algorithm, Image, Region of Interest, Watermarking.

1. INTRODUCTION

Nowadays, digital data are increased in digital media and protecting these data against abusing is an important issue. There are three main categories in protecting these data against misuses and attacks for removing or damaging embedded data known as cryptology, steganography and watermarking [2]. The latter is used mostly in digital communication. Watermarking is the science of hiding trademark, logo or copyright into the digital data.

Watermarking is divided into two main categories which are known as spatial domain and transform domain. Each of these categories has their advantages and disadvantages. However the spatial domain has low complexity implementation, due to better robustness and fidelity the latter mostly is used rather than the spatial domain.

The transform domain based on its transform function is divided into many subdivisions. The mostly used transform domains are Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT). Watermarking in the DWT domain allows localization in both time and spatial frequency domain and it has higher compression ratio which is relevant to human perception [2].Whereas it has high complexity and time consumption and it has noise near the edges of the image after transform. Watermarking in the DCT domain has a good invisibility and it will not get influenced by embedding and in extracting of the watermarks they will not removed, if they embedded into the best coefficients. This will be done with genetic algorithm here.

This paper is organised as follows. Firstly, the regions of interest factors in digital image watermarking are introduced. Secondly, the embedding algorithm is proposed and at the end the experimental results are shown.

2. REGIONS OF INTEREST

Finding the best regions or some coefficients for embedding the watermarks into the cover image is a hard decision. There are some algorithms for finding these regions which are known as regions of interest (ROI); the regions which are known as the texture areas that have more information than the other areas in images. The simplest way of dividing idea to images into textured and non-textured can be separated manually. But, deciding whether the selected areas are textured or not is another problem that should be done precisely. Due to doing this division manually it can also have much more time consumption rather than dividing automatically. Also the textured areas of different images are different and when there are a lot of different images for embedding this division may be selected wrongly.

2.1. THE CENTRE OF INTEREST PROXIMITY FACTOR

The idea of The Centre of Interest Proximity Factor (CIPF) is introduced by [5] and it is as follows. For each 8*8 blocks of cover image the Euclidean distance r(m,n) between the centre of the block with coordinates (m,n) and the centre of interest (with coordinates (M/2,N/2) if the centre of interest is as the same of the centre of image) is determined and this distance then normalized over the diagonal [5]. Corresponding to the other factors which are introduced later this normalized distance value should be in the range of the others and because of that this value processed through a transfer function as (1).

$$F(rnorm) = \frac{1}{\pi}.\tan^{-1}\left(k.(rnorm) \quad \frac{2}{3}\right) + \frac{1}{2} \tag{1}$$

Where (r norm) is the normalized distance value and k is selected in [10-25].

2.2. The Complexity Factor

In [5] it is shown that it is not a good idea to use variance values of the images to realize how much watermarks can be embedded into the cover image without any major perceptual distortion in cover image. It is claimed that for two similar images the variance values are equal whereas it can be embedded more information to one of those images rather than the other one. It is measured as (2).

$$CF_i = weight.|D_i'| \tag{2}$$

Where D_i is a vector (1*63) including the DCT coefficients of the i^{th} block of the image according to the standard zigzag scan.

2.2. The Priority Coefficient

Each of the aforementioned factors has its ability to whether robust against some particular attacks or imperceptibility after watermarking. According to what the application of watermarking is, the owner of digital media can use one of those factors. If both robustness and imperceptibility are important for the user, he can join the aforementioned factors together as (2)(**3**).

$$PC_K = CIPF.CF_K \tag{3}$$

Where PC is the Priority Coefficient that sorts the blocks of the cover image.

3. EMBEDDING ALGORITHM WITHOUT GENETIC ALGORITHM

At first the embedding algorithm which has been used in the DCT domain by [7,8] is introduced then the embedding algorithm by using genetic algorithm (GA) will be introduced in the next section in a row.

Let I be an image with M_1*M_2 pixels that M_1 and M_2 are the number of rows and columns in the cover image, respectively. In the DCT domain the image is divided into 8*8 blocks, so there are (M_1*M_2/8*8) blocks in the cover image. We represent the number of row and column blocks by U and V, respectively. After implementing DCT domain on the cover image, the correlation values of blocks are computed by (3)(**4**).

$$R(i,j)=\frac{1}{U*V}\sum_{u=1}^{U}\sum_{v=1}^{V}C_{uv}(i,j)/C_{uv}(0,0) \tag{4}$$

Where R(i,j) is the correlation value, C_{uv}(i,j) is the AC coefficient and C_{uv}(0,0) is the DC in each blocks.

As the [7] embedding algorithm, for embedding the $\hat{C}_{uv}$ should be computed which is shown in (3). The new coefficients in transformed blocks after embedding are calculated as (5).

$$C_{uv}^{\wedge}=C_{uv}(0,0)R(i,j) \tag{5}$$

$$C_{uv}^{'}=\begin{cases} C_{uv}^{\wedge}(i,j)-\alpha, & if\ \ C_{uv}^{\wedge}(i,j)-C_{uv}(i,j)<\alpha\ \&\ w=0 \\ C_{uv}^{\wedge}(i,j)+\alpha, & if\ \ C_{uv}^{\wedge}(i,j)-C_{uv}(i,j)<\alpha\ \&\ w=1 \\ C_{uv}(i,j), & else \end{cases} \tag{6}$$

Where **α** is selected manually and with experience the best value can be chosen. W is the watermark value in the binary watermark image.

4. EXTRACTING ALGORITHM

For extracting watermark bits in the watermarked image the cover image is not needed. In other words, the blind watermarking is presented here.

Let $I^{'}$ be the watermarked image. At first, it is transformed by DCT. Secondly, the correlation values for all blocks are calculated as (6).

$$R(i,j)=\frac{1}{U*V}\sum_{u=1}^{U}\sum_{v=1}^{V}C_{uv}^{'}(i,j)/C_{uv}^{'}(0,0) \tag{7}$$

Where $C'_{uv}(i,j)$ is the i^{th} row and j^{th} column of the transformed block. The extracting algorithm is as (7).

$$W^{\wedge}=\begin{cases} 1, & if\, C_{uv}^{'}(i,j)\geq C_{uv}^{'}(0,0)R^{'}(i,j) \\ 0, & if\quad else \end{cases} \tag{8}$$

Where $\hat{W}$ is the extracted bit in the watermarked image.

5. EMBEDDING WITH GENETIC ALGORITHM

In this section, the use of GA [1, 3-12] in the watermarking algorithm is illustrated. The main algorithm was used in [6] and it is as follows;

- The multi-objective genetic algorithm is used, means the fitness function in GA is included robustness and perceptibility factors.
- The value of α is considered as embedding strength coefficient and the best value is calculated by trial and error.
- The chromosome representation is 32bit chromosome which can be decreased to 16 bits. Table 1 shows this chromosome representation.

Table 1. Chromosome representation.

	8 bit	8 bit	4 bit	4 bit	8 bit
Chromosome Representation In GA	Row Number Of Blocks (U)	Column Number Of Blocks (V)	Row Coefficient Number Of Blocks (I)	Column Coefficient Number Of Blocks (J)	α value

6. EVALUATION OF EMBEDDING ALGORITHM

The multi-objective genetic algorithm (MOGA) is used here. The Peak Signal to Noise Ratio (PSNR) and Bit Error Rate (BER) are considered as fitness function for MOGA. The PSNR and BER calculations are as (8)**(1)** and (9), respectively.

$$PSNR = 10.\log_{10} \frac{255^2 * M_1 * M_2}{\sum_{i=1}^{M_1} \sum_{i=2}^{M_2} (y(i,j) - y(i,j))^2} \tag{1}$$

$$BER = \frac{\sum_{i=1}^{N} w \oplus w_i^{'}}{N} \tag{2}$$

Where M_1 and M_2 are the numbers of rows and columns of cover image. y(i,j) and $y'(i,j)$ are the cover image and watermarked image pixels, respectively. N is the total number of watermark image, W and $W^{'}$ are the watermark image bits and the extracted watermark bits.

7. EXPERIMENTAL RESULT

In this paper, the Cameraman with 256*256 and Flower with 32*32 pixels are considered as cover and watermarked images, respectively. Firstly, the regions of interest of the cover image is extracted and the best blocks for embedding robust against cropping attack and with the best imperceptibility are selected by pre-processing factors. The part of the sorted blocks of Cameraman is shown in Table2.

Table 2. Original and Sorted image blocks of Cameraman.

Original image blocks	1	2	3	4	....	1024
Sorted image blocks	367	910	274	308	....	567

The first column in Table 2 shows the original image blocks, whereas the second column shows the sorted blocks based on the region of interest criterion. After selecting the best blocks, the GA is used to find the best coefficients of the sorted blocks for embedding. For embedding using GA, the number of watermark bits in each block can be chosen 2, 4 or 8. In this paper this number is equal to 2 bits per block. So, the number of bits per block for watermarking can be changed according to its size of the cover image and the operator. The more the number of bits for embedding in each blocks, the more the degradation in imperceptibility and robustness will be occurred. The experimental results are shown in Table 3. The results of watermarked image after some attacks are shown in Figure 1.

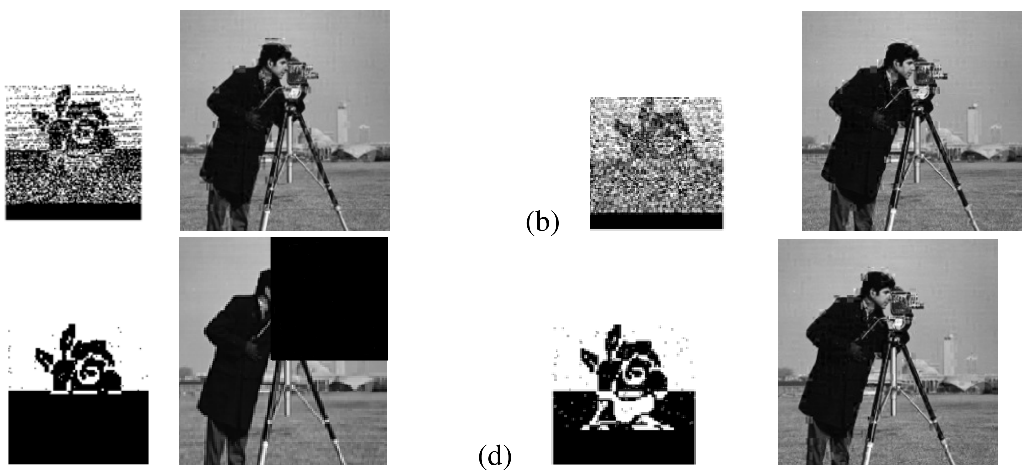

Figure1. The watermarked image and extracted watermark after (a) Median filter, (b) Histogram equalization, (c) Scaling (30%), (d) Cropping attacks.

Table 3. Comparison of Wang & Presented algorithm.

COMPARISON	**PRESENTED ALGORITHM**		**WANG ALGORITHM**	
Wang & Presented Algorithms	PSNR	1-BER	PSNR	1-BER
Salt & Pepper	29.89	0.582	26.57	0.68
Median filter	27.34	0.543	21.13	0.54
Sharpening	26.42	0.437	20.53	0.43
Motioning	27.65	0.561	25.72	0.41
Blurring	25.72	0.529	25.81	0.46

Histogram Equalization	28.32	0.418	20.11	0.22
Scaling (30%)	35.14	0.324	34.51	0.23
Cropping	18.29	0.663	15.31	0.39

8. CONCLUSION

The watermarking robust against the cropping attack and with good imperceptibility is introduced here by using some pre-processing factors which are known as region of interest factors. After sorting the cover image blocks, the multi-objective genetic algorithm is used for finding the best coefficients in each sorted blocks. The results show improvement in the watermarking robustness and imperceptibility criteria comparison to the conventional watermarking algorithms.

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