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Digital Image Watermarking Using Edge Detection and Genetic Algorithm

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Abstract— ***Watermarking in the regions which knew as an edge of the image with some filters which uses as an edge detection improves the watermarking results. But since there is an embedding strength coefficient, finding the best values for this coefficient needs an optimization work. Here, genetic algorithm is used for finding the best values of embedding coefficients.***

Keywords— ***Edge detection, Genetic algorithm, Image, Watermarking, Embedding strength.***

I. Introduction

Steganography and watermarking have developed based on the same theoretical roots, that we want to keep a secret message hidden from an party. A widespread term describing a broad area of secure communication methods is watermarking. Watermarking refer to either making the watermark imperceptible or keeping the existence of the watermarking secret. Watermarking is one of the ways to protect authentication of digital data including image, video, voice or even text in the insecure channels like Internet from intentional or malicious attacks.

During these days using watermarking is known as an important and undeniable way of transmitting digital data.

Watermarking is divided into two main categories known as spatial domain [i] and transform domain [ii]. Nowadays, watermarking in the transform domain has much more attraction than spatial domain because of much more imperceptibility and robustness against different attacks. There are many transform domains based on the transform functions. Some of the most important ones are Discrete Fourier Transform[1] [iii], Discrete wavelet Transform[2] [iv] and Discrete Cosine Transform[3] [iv].

In this study the latter one, Discrete Cosine Transform is used and the watermark embedding is done in a non-uniform manner with criteria based on the edges of the host image and the watermark.

These days, Genetic algorithm[4] for finding the most optimized results in the predefined criteria in the image watermarking is attracted attentions. One of the reasons of it is for finding the best embedding strength coefficient in the embedding [v-xi].

The human visual system exhibits reduced sensitivity to distortions in the regions of an image where the rate of change is significant [xii]. Due to existence of noise near edges of images in the DWT the results show that embedding in the DCT domain has better imperceptibility near edges rather than DWT domain.

This paper is organized as follows; firstly, the filter which is used here, Prewitt, is introduced. Then the embedding algorithm is expressed. At the end, the experimental results are shown.

II. Prewitt edge detection

There are many edge detection techniques [xiii,xiv].In this paper, Prewitt filter [xv] is used for detecting the edges of the cover image for watermarking. A watermark with significant value can be robust around edges and texture areas of an images, it would be imperceptible as well [xii]. The edge detection matrices (also known as 3*3 Kernels) are as (1), (2).

$$Gx = \begin{bmatrix} -1 & 0 & +1 \\ -1 & 0 & +1 \\ -1 & 0 & +1 \end{bmatrix} * I \quad \textbf{(1)}$$

$$G_y = \begin{bmatrix} -1 & +1 & +1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} * I \quad \textbf{(2)}$$

Where I, G_x and G_y are the cover image, gradients of the image, respectively. The result of performing Prewitt filter into the Cameraman image is illustrated in Figure 1.

Figure 1.Cover image and cover image after edges detection (Prewitt filter).

II. Embedding algorithm

In GA parameters are represented as binary strings and known as chromosomes. Genes in the chromosomes are sorted for minimizing or maximizing the fitness function values [xvi].

Embedding flowchart is depicted in Figure 2. The main program is based on the edge detection and GA.

[1] DFT
[2] DWT
[3] DCT
[4] GA

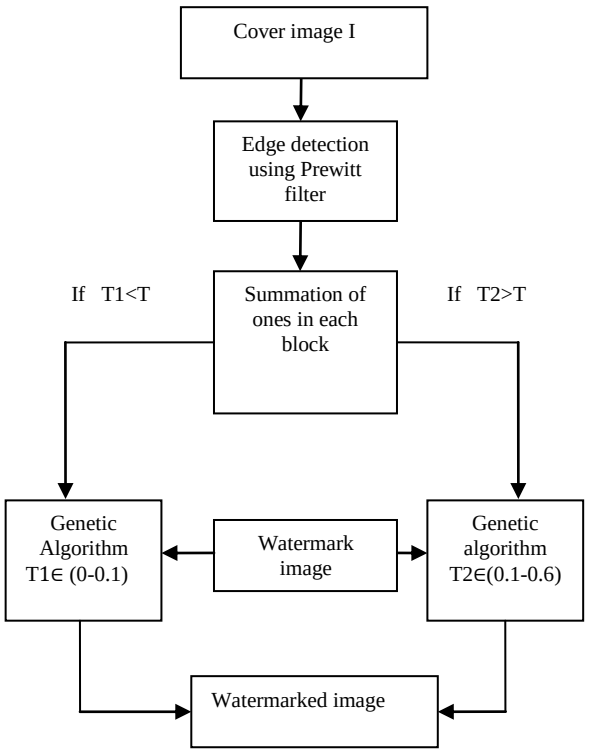

Figure 2. Embedding Flowchart

Firstly, the cover image is transformed using DCT. For each block of the DCT coefficients of the image, Prewitt filter is performed to achieve the edges of the blocks. If a pixel be an edge of the image, the bit representation of it after performing Prewitt filter will be one, otherwise it will be zero. Then, in each block the number of ones and zeros is considered. If the number of ones is equal or greater than some predefined threshold, the embedding will perform with a great embedding strength coefficient and if not, it will perform with a small one. The embedding algorithm is as (3).

$$block\_dct\_embd = block\_dct * (1 + Alpha * mark(k)) \quad (3)$$

Where block_dct_embd is the watermarked block, block_dct is the original DCT block, Alpha is the embedding strength coefficient.

In this paper, the optimized embedding coefficient is achieved by using GA. First, two embedding coefficients are considered as an initial value of Alpha and represented as a binary format known as the chromosomes. Then all of the GA operations such as selection, crossover and mutation are performed into these chromosomes.

Because of better imperceptibility different embedding coefficients are considered. This means that it is important to choose a small embedding strength in the regions or blocks which is not known as an edge of the image and vice versa for improving the imperceptibility of the watermarking. For instance, the results show that choosing 0.42 for regions which is known as the edges of the Lena image and 0.003 for regions which is not the edges of that, is the best choice for having the most imperceptible watermarking.

In this paper, 8-bit binary representation is considered and can be up to 16 bits for better results but this cause the more time consumption.

The limitation for the strength embedding coefficient for those blocks which have had values more than threshold value is between [0.1-0.6] and for those which have had less than threshold value is between [0-0.1].

III. Results and Tables

In this section, the results of proposed algorithm are represented. The predefined values and parameters are as follows. The threshold value is 5, the initial population is between2-20, number of iterations is equal to 5, the mutation rate is 0.001 and the watermark is considered as random values such as Gaussian noise and the number of that is equal to the cover image blocks.

For reducing the time consumption in proposed algorithm, some techniques are used here. In this way that the GA operation does not perform into blocks which the number of ones in that block was equal to some previous block and the previous embedding coefficient is considered.

Another technique which is used here is that the number of ones in one block is considered with some logical error. For example, if the number of ones in one block was equal to 10 and there are some blocks before with 8, 9, 11 or 12 number of ones, the embedding coefficient is considered equal for all these blocks. Also this technique is considered for non-edges blocks.

By doing these two techniques, substantially the time consumption of watermarking algorithm is reduced.

The Gaussian noise as a watermark and cameraman as a cover image are considered with size of 256*256 and 32*32, respectively. They are shown in Figure 3.

The experimental result is shown in Figure 5 and the comparison with the previous watermarking algorithm [iv] is depicted in table Table 1.

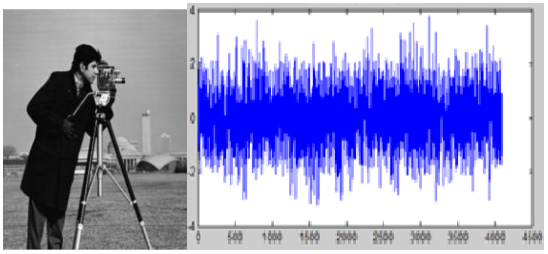

Figure 4. Cover image and random Watermark bits.

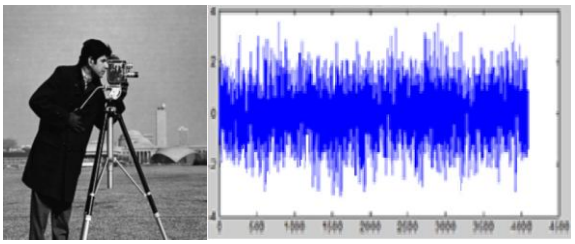

Figure 5. Watermarked image (Alpha1=0.01, Alpha2=0.24) and extracted watermark

Table 1. Results comparison between proposed algorithm and Kumar [iv]

RESULTS COMPARISON	PROPOSED algorithm	Kumar algorithm
PSNR WITHOUT ATTACK	45.8	42.4
BER AFTER JPEG ATTACK	0.47	0.49
BER AFTER MEDIAN FILTER	0.58	0.57
BER AFTER SALT &PEPPER NOISE	0.51	0.63

IV. Conclusion

Results show that watermarking in the regions which is known as the edges of the image has better result than other regions. In this paper, embedding in these regions is performed. Also genetic algorithm is used for optimizing the different embedding strength coefficients.

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