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A NOVEL APPROACH IN IMAGE WATERMARKING WITH DISCRETE WAVELET TRANSFORM

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Abstract: In this paper we present a new watermarking scheme for still image data. Most of the recent work in watermarking can be grouped into two categories: spatial domain methods and frequency domain methods. We introduce a novel approach of watermarking which involves embedding the watermark in the discrete wavelet domain. We make use of a multi resolution data fusion approach in which the image and watermark are both transformed into the discrete wavelet domain. The resulting image pyramids are then fused according to a series of combination. After watermark insertion, inverse DWT is applied to the sub-bands with modified coefficients to obtain the watermarked image. For watermark extraction, a threshold-based decoder is designed. Embedding and extraction process are characterized with parameters and genetic algorithm is used for parameter optimization. Optimization is to maximize the values of peak signal-to-noise ratio of the watermarked image and normalized cross correlation of the extracted watermark. The performance of the proposed scheme is compared with the existing schemes and significant improvement is observed.

Keywords: watermarking, watermark insertion, watermark extraction, Genetic Algorithm.

1. INTRODUCTION

Advanced researches have intensively investigated the characteristics of wavelet filters, adaptive wavelet decomposition structure for coding optimization and different combination of mathematical operations for digital image watermarking implementations.

Among these studies, there are researches shown that the combination of wavelet filters or filter bank decomposition structure can be implemented as the function of the keys for the watermarking. Even this property provides the flexibility for practical usage, the false alarm of the rightful ownership verification is essentially existed since the resolution requirement for the transformed coefficients can he less demanded than other applications like compression or encryption. Image watermarking is the process of inserting an image called watermark in another image called cover image. Outcome of this insertion process is called watermarked image. The insertion process must be in such way that watermark is extractable from the watermarked image.

The main problem in digital image watermarking is survival of the watermark when the watermarked image is subjected to image processing operations (image attacks) like compression, low-pass filtering, high-pass filtering, histogram equalization etc. Watermarking schemes are called robust if the survival capability of the watermark is high.

If the extraction process does not require watermark or cover image then the scheme is called oblivious watermarking. Several algorithms are available in the literature for robust image watermarking. But, there are some limitations in the existing algorithms. Designing a robust watermarking system is still a challenging problem.

Watermark embedding in the cover image requires modification of some features of the cover image according to the symbols of the watermark. Selected features of the cover image can be pixels or transform coefficients.

If the watermarking algorithm modifies the cover image pixels then it is called spatial domain watermarking. Transform domain watermarking algorithms modifies the transform coefficients of the cover image. Spatial domain algorithms are simple and data embedding capacity is more.

But they are not robust against image attacks. On the other hand, transform domain algorithms are robust against image attacks and the amount of robustness varies from attack to attack. No single algorithm is available with which watermark survives for all possible image attacks. Hence, there is a scope for improvement in the excising watermark algorithms, an attempt is made to improve the performance of some of the existing transform domain based robust watermarking algorithms.

2. BACKGROUND

Transform domains have been extensively studied in the context of image coding and compression. The advantages of using wavelet transform domain are inherent robustness to JPEG 2000 compression and possibility of minimizing computation time by embedding watermarks inside a JPEG 2000 encoder. Also Wavelet Transform provides the property of windows vary.

So, to isolate signal discontinuities one would like to have some short basis functions. In order to obtain detailed frequency analysis, one would like to have some very long basis functions. i.e. wavelet analysis provides immediate access to information that can be obscured by other time frequency methods such as Fourier analysis. Wavelet analysis has begun to play a serious role in a broad range of applications including signal processing, data and image compression, solution for partial differential equations, modeling multiscale phenomena and statistics etc. It provides a systematic way to represent and analyze multiscale structure. It also provides a systematic and universal representation for wide classes of functions.

Multiscale representation is a representation selected for the convenience of the analyst, because it often provides an efficient representation of information for storage, calculation or communication of information.

The Multi Resolution Analysis underlies the theory of wavelets where the information is split into a principal part and a resolution part. A wavelet matrix is a generalization of square orthogonal or unitary matrices to a larger class of rectangular matrices. It corresponds to the electrical engineers multi rate digital filter banks where each row in the matrix corresponds to one filter in the filter bank. The fundamental properties of wavelets are, Compact support - each term in a wavelet series has compact support and no matter how short an interval is, there is a basis function whose support is contained within that interval. Compactly supported wavelet basis function can model local behavior effectively because they are not constrained by properties of the data far away from the location of interest. Orthoganlity - the terms in wavelet size are orthogonal to one another. Information carried by one term is independent of information carried by other term.

There is no redundancy in representation. i.e. neither computing cycles nor storage are wasted as a result of coefficients redundancy. Multi resolution representation - provide a simpler and more efficient representation than conventional mathematical representation.

Wavelet packets are particular linear combination of wavelets. They form bases which retain many of the orthogonality, smoothness and localization properties of their parenet wavelets. In Adapted waveforms, we have a choice among an infinte set of basis functions, we may wish to find the best function for a given representation. i.e. A basis adapted waveform is the best basis function for given image representation. The chosen basis carries substantial information about the signal.

The Wavelet's transform has the ability to decompose an image into statistically distinct frequency bands. The wavelet is able to convert frequency compact energy into a small set of low frequency coefficients and also to spatially compact energy into a small set of high frequency coefficients. Wavelet Transforms understand Human Visual System (HVS) more closely than Discrete Cosine Transformation (DCT) and visual artifacts are much less in DWT than in the DCT [1,2,5]. DWT has gained interest among researchers because of its suitability to the HVS behavior.

3. GENETIC ALGORITHM

The genetic algorithm is used to minimize the non-linear error function using the GA parallel search capabilities in the huge FIR filter coefficients continuous solution space. To present the algorithm operation, its basic elements can be described as follows:

Population: The population of the genetic algorithm consists of a given number of individuals representing each one a possible optimum FIR filter. Each individual chromosome is represented by the coefficients set, each one a continuous real number, initialized setting each coefficient with a real random value of a Gaussian distribution with predefined mean and variance values.

Fitness Function: At each new generation of the genetic algorithm, the offspring is created based on the fitness function.

Selection: Based on the fitness function, each individual is selected using a roulette-wheel selection method, meaning that to each individual a slice in the wheel is assigned, its width proportional to the individual fitness. In addition, the algorithm uses elitism in the selection, meaning that a predefined number of best individuals are always selected for the next offspring.

Crossover: The crossover genetic operation is defined for the current implementation as follows. A randomly chosen crossover position in the parents filter coefficients set is defined. Then the parents filter coefficients are swapped over this randomly generated crossover position.

Mutation: With a predefined probability, each parent chromosome (filter coefficient set) is mutated adding a small random value of a Gaussian distribution with predefined mean and variance values.

Watermarking problem can be viewed as an optimization problem.

In this work, GA is used for solving the optimization problem. PSNR and NCC are the two important characteristic parameters of a watermarking system. The amount of distortion introduced to the host image during embedding process is inversely proportional to PSNR. NCC indicates the amount of similarity between original watermark and extracted watermark. The watermarking scheme is characterized with parameters and GA is used to find the optimum values of parameters to obtain the specified performance of the watermarking system in terms of PSNR and NCC.

4. PROPOSED METHOD

Watermark Insertion:

Embedding a binary watermark into the 8-bit grey-scale cover image is discussed here. Consider the cover image of size 90 ×90 and transform it using the third-level DWT. This transformation produces ten sub-bands. One or more sub-bands can be used for watermark embedding. Depending upon the specific watermarking requirements, sub-bands will be selected. The requirements considered in this work are imperceptibility, robustness and data embedding capacity. For satisfying those requirements and based on the reasons , both LH3 and LH2 are chosen for embedding 32 × 32 size watermark image. Coefficients of LH3 and LH2 are grouped into various blocks. Grouping is in such a way that each block should contain one coefficient from LH3 and four coefficients from LH2. In each block, one bit of information is embedded by modifying the two coefficients in that block. The two coefficients in a block are the first minimum and the second minimum.
Following are the steps for insertion of watermark:

1. Decompose the original cover image into various sub bands using the three-level DWT.
2. Organize the coefficients of LH2 and LH3 into five element blocks (4096 blocks).
3. One coefficient from LH3 and the four non-overlapping coefficients from LH2 are included in each block.
4. Let min and sec are the first minimum and the second minimum, respectively, in the ith block.
5. Let di denotes the difference between sec and min. Compute d_i for all i ¼ 1 to 4096.
6. Compute the mean value of the above differences and identify it with dmean.
7. Consider a binary watermark of size 64 × 64 (4096 bits).

Let w_i represents the ith watermark bit.

Watermark Extraction:

The watermark extraction procedures are also summarized as the following:
1. Key information restoration and decomposition of the watermarked image
2. Watermark extraction from the selected band, descramble and renormalization.
3. Correlation calculation.
In fact this is the reverse procedure of watermark insertion. All The above steps in water mark insertion are repeated from bottom to the top.

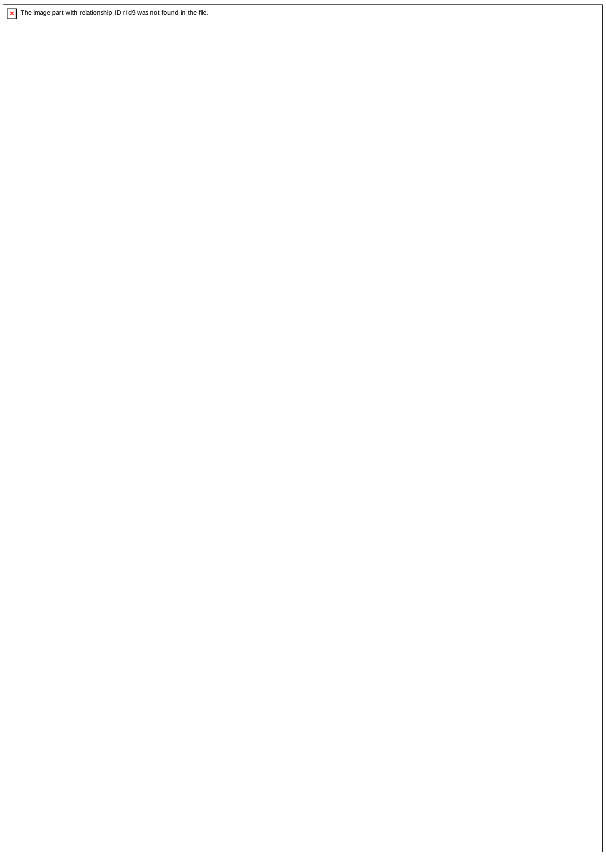

Figure 1 Watermark insertion algorithm

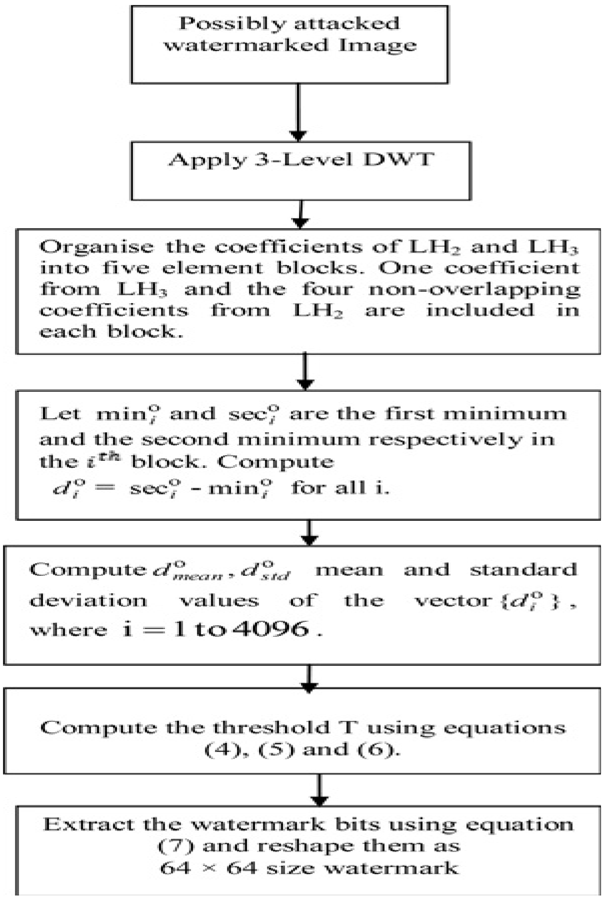

Figure 2 Extraction Algorithm

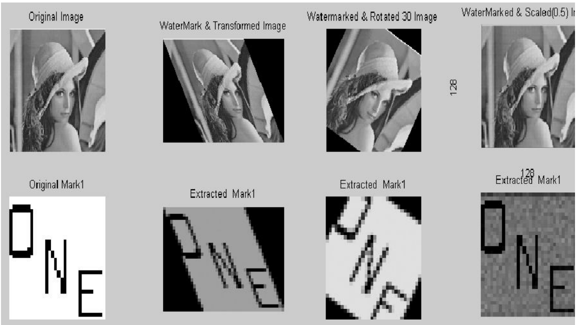

Figure 3 Watermark Embedded and Extracted after Attacks

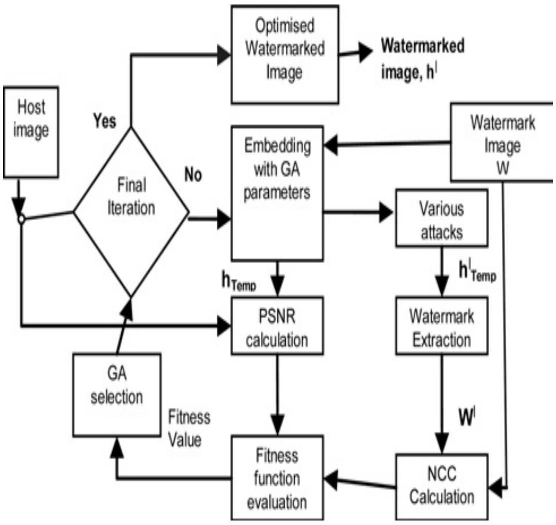

Figure 4 Genetic Algorithm based Watermark Insertion

5. CONCLUSIONS

This work showed a robust watermarking scheme based on DWT. Watermark is embedded in the detail sub-band coefficients of the cover image. LH2 and LH3 sub-band coefficients of the cover image are used to form five-element blocks. In each block, the first minimum and the second minimum are identified and one watermark bit is embedded in them. To embed a 0, the difference between the first minimum and the second minimum is reduced to zero and to embed a 1, the difference is increased to a significant value. This embedding process is characterized with four parameters. GA is used to find the optimum values for the parameters. Optimization is to maximize the values of PSNR and NCC. The performance of the proposed method is tested with watermark images of different sizes. To embed a 32 × 32 watermark on 90 ×90 image, LH2 and LH3 are used.

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