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Performance Optimization of Wavelet Based Digital Image Watermarking Using Genetic Algorithm

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Abstract:
Nowadays, Watermarking plays a vital role in the world. In this paper, we propose a digital image watermarking technique using wavelet based transforms. The watermark is embedded to the transform coefficients larger than some threshold values. Genetic algorithm (GA) based optimization technique is implemented, in order to find the optimal threshold values. This method is more secure and robust to attacks. We compare the genetic based experimental results with conventional Discrete Wavelet Transform (DWT) and Packet Wavelet Transform (PWT).

Keywords*: Digital watermarking, Discrete wavelet transform, Wavelet packet transform, Genetic algorithm, PSNR,.*

1. Introduction

Image watermarking provides copyright protection of images by embedding secret information on the original image. Digital watermarking is defined as a process of embedding data into a multimedia object to help to protect the owner's right to that object[2]. The main features of watermarking are capacity of hide, imperceptible, and robustness.

In general, the watermarking can be implemented in spatial domain and transform domain. The transform based watermarking is more robust and secure [6]. Most of the transformation domain watermarking schemes works with Discrete Cosine Transform (DCT), and Discrete Wavelet Transform (DWT). Robustness can be achieved if modifications are made to the host image either in spatial or transform domain.

At first, A Singular Value Decomposition (SVD) based watermarking technique and its variations have been implemented. The watermark can be scaled by a scaling factors[5]. It is used to control the strength of the watermark. In this paper we apply a optimization based watermarking technique using genetic algorithm. The proper scaling factors are efficiently determined by genetic algorithm.GA operates through a simple cycle of stages as given below:

- Creation of 'population' of strings.
- Evaluation of each string.
- Selection of 'best' strings and
- Genetic manipulation to create the new population of strings.

Genetic Algorithms are inspired by Darwin's theory about evolutions. The basic principles of GA were first proposed by Holland and inspired by the mechanism of natural selection where stronger individuals would likely to be the winner in the competing environment.

GAs are particularly suitable for solving complex optimization problems and hence for applications that required adaptive problem - solving strategies[7]. In addition, GAs are inherently parallel, since their search for the best solution is performed over genetic structures that can represent a number of possible solutions. Algorithm is started with a set of solutions (represented by chromosomes) called populations [4]. This is motivated by a hope, that the new population will be better than the old one. Solutions which are selected to form new solutions (offspring) are selected according to their fitness. This is repeated until some condition (for example number of populations or improvement of the best solution) is satisfied.

2. Image Transformation

In this paper, we propose a watermarking scheme based on two transform namely GA based Discrete Wavelet Transform (DWT), and Wavelet Packet Transform (WPT)[3]. In DWT works with the principle of Multi Resolution Analysis (MRA). It employs scaling and wavelet function, which are associated with Low pass and High pass filters respectively. It analyse the signal at different frequency bands with different resolutions by decomposing the [9]. It transform the signal from time into time-frequency domain.

Finally two coffecients are obtained namely approximation coefficients and detail coefficients which are the high scale low frequency components, low scale high frequency components respectively.

$$Y_{high}(n) = \sum_n x(n) * g(2k - n)$$

$$Y_{low}(n) = \sum_n x(n) * h(2k - n)$$

where $Y_{high}(n)$ and $Y_{low}(n)$are the outputs of the highpass and lowpass filters respectively after subsampling by2.

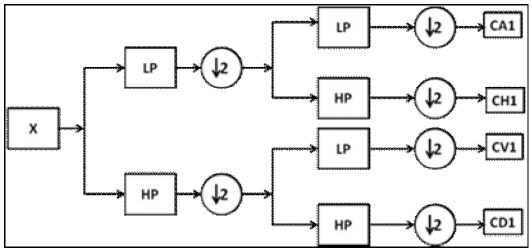

Figure 1: decomposition using DWT

A single level decomposition using DWT as shown in Fig.1. Input image is given to both high pass and low pass filter respectively. The highpass only allow the high frequency and the low pass allows the low frequency. Avoid the doubling of data, downsampling will be used. In the first stage row wise downsampling conducted. Again the same process repeated. In the next stage column wise downsampling presented. Finally it produce 4 sub-bands respectively as shown above. The CA1 represent the approximation coefficient, CH1 is the Horizontal detail, CV1 indicate the Vertical detail and finally the CD1 is the Diagonal detail.

Genetic algorithms are search algorithms based on mechanics of natural selection and natural genetics. It is based on survival of the fittest among string structures. A new set of artificial creatures (strings) is created using bits and pieces of fittest of the old creatures[4].

- In genetic algorithms, the parameters are represented by an encoded binary string called the “chromosome” and the elements in the binary strings or the “genes” are adjusted to maximize or minimize the fitness values.
- The fitness function has to be carefully selected specific to a particular application and the kind of optimization required. Thus, the entire process of genetic algorithm starts with a set of proposed solutions randomly generated and tries to produce further possible solutions to achieve the desired optimization.

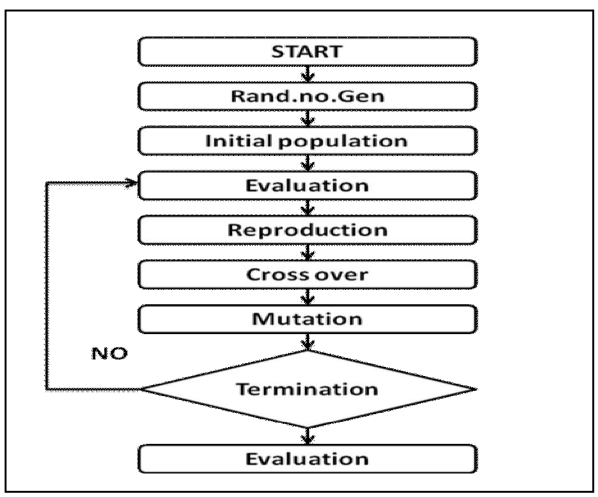

Figure 2: flowchart of GA

Figure 2 represents the flow chart of GA.

The Components of GA are[8] ,

2.1. Fitness Value

A fitness function is a particular type of objective function that is used to summarise, as a single figure of merit, how close a given design solution is to achieving the set aims. Cost function –fitness function – To be minimized or maximized.

2.2. Selection

It is based on the basis of survival-of-the-fittest mechanism. Chromosome is selected based on the fitness value.

2.3. Crossover

The chromosome with the higher fitness values generate more offspring.

2.4. Mutation

After Crossover, the strings are subjected to mutation. Mutation of a bit involves flipping it changing 0 to 1 and vice versa with a small probability.

The wavelet transform often fails to accurately capture high-frequency information, especially at low bit rates where such information is lost in quantization noise. Coifman et al. developed a technique called wavelet packets (WP) that is better able to represent high-frequency information. A multilevel wavelet filter bank involves iterating the lowpass – highpass filtering and downsampling procedure only on the output of the lowpass branch of the previous stage. Coifman et al. formulated an extension of the octave – band wavelet decomposition to full tree decomposition by allowing the lowpass – highpass filtering and downsampling procedure to be iterated also highpass branch in the tree. The new basis function, called wavelet packet as follows.

The discrete wavelet transform (DWT) can be characterized as a recursive application of the highpass and lowpass filters that form a Quadrature Mirror filter (QMF) pair [1]. The calculation of the DWT begins by filtering a signal by the highpass and lowpass filters and then downsampling the output. The computation proceeds by applying the QMF pair to lowpass filtered output of that previous level.

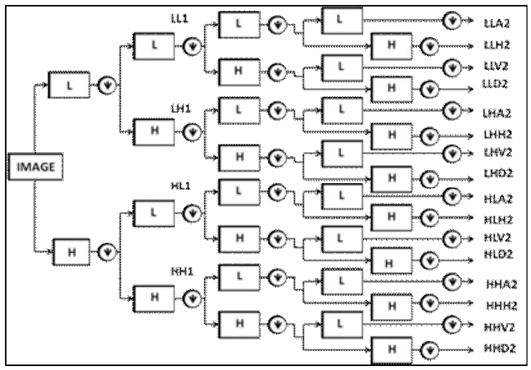

Figure 3: wavelet packet decomposition

Wavelet packets are generated by filtering the signal in both lowpass and highpass as shown in Fig.3. However, now the computation proceeds by applying the QMF to not only the lowpass output but to the highpass.

3. Proposed Work

In our proposed methodology, the input image is decomposed by 2-level DWT. The embedding factor is tuned by genetic algorithm. The embedding scheme is shown in Fig 4.

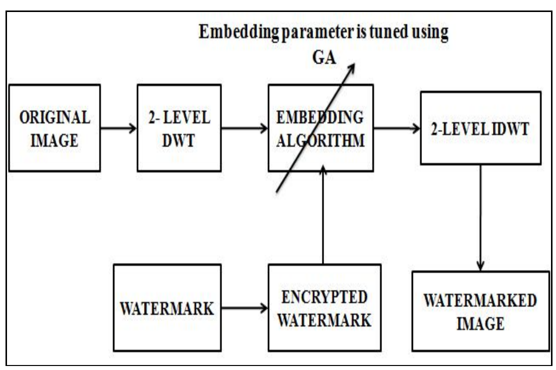

Figure 4: prposed embedding scheme.

- Define the fitness function, number of variables and the value for population size, crossover rate, mutation rate, and number of generations (or any terminating criteria).
  ff = PSNR + SM* 100
- Generate the initial population randomly (values of α in the range of 0 to 1) with step size of 0.1 (100 values).

The watermark is embedded into a intermediate frequency sub-band whose having high PSNR value. By applying the Inverse Discrete Wavelet Transform (IDWT), we can reconstruct the image , it produce the Watermarked image. In the same procedure repeated for GA based wavelet packet transform also.

4. Simulation Results

In this proposed watermarking procedure, the lena image is taken, it having the size 256x265. The umbrella is the watermark image, size is 64x64. Both the images are shown in Fig 5 and 6. Also Fig 7 shows the DWT of the lena image for one level. CA1 is an approximation sub image of the input image, CH1 is the detail containing information in horizontal, CV1 is another detail containing information in vertical and CD1 is the detail containing diagonal information. CA1 band can be classified as most important, and other detailed bands can be classified as less important. The LLI band can be decomposed further in the same manner, thereby producing another four sub-bands as shown in Fig 8.

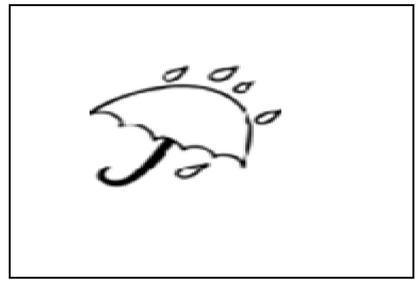

Figure 5: Lena image Figure *6: watermark image*

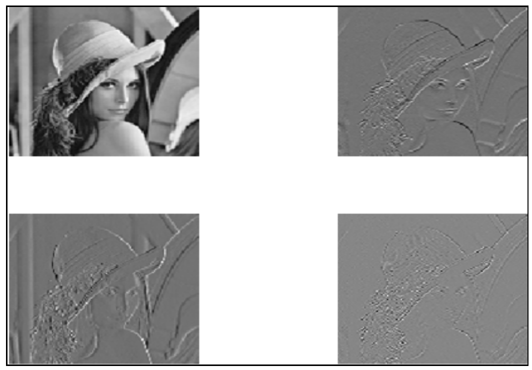

Figure 7: 1 level decomposition using DWT

The umbrella image is embedded into the middle frequency sub-bands of the lena image.To evaluate the robustness of the watermarking scheme, several attacks including the Gaussion noise, Salt & Pepper noise, Median filtering operation, Cropping and Rotation are performed against watermarked image.

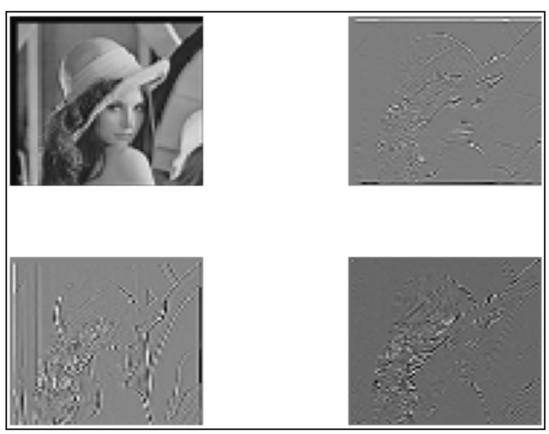

Figure 8: two level decomposition using DWT

Figure.9 shows the watermarked images obtained from DWT, DWT with GA and WPT.

DWT *GA - DWT* *GA-WPT*
PSNR:21.6578 *PSNR:30.0194* *PSNR:39.9576*

Figure 9: Watermarked images using three Transforms

IMAGES	DWT	GA- DWT	GA-WPT
Watermarked image	21.6578	30.0194	39.9576
Gaussian noise	18.8933	20.5513	34.8348
Salt & pepper noise	23.7518	28.8722	35.4590
Median filter	16.0048	18.4768	34.2108
Crop image	28.1830	28.6318	29.7723
Rotate image	27.2126	27.2716	27.2750

Table 1: PSNR values(dB) for watermarked image under various attacks.

The PSNR values for watermarked image under various attacks using three transform are tabulated in table 1,and Fig.10 shows the watermarked image added with Gaussian noise, salt & pepper noise, median filtered, cropped and rotated image correspondingly for GA based Transform.

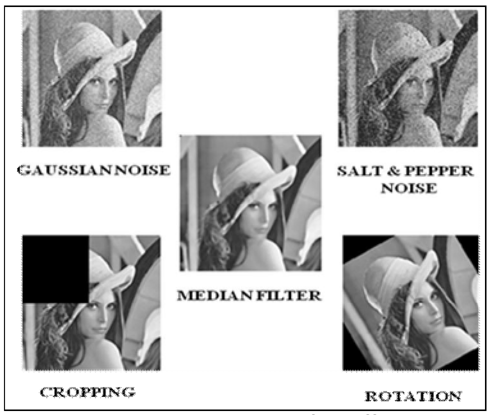

Figure 10: Watermarked images for different attacks.

5. Conclusion

Digital Image Watermarking is performed using Discrete Wavelet Transform and Wavelet Packets Transform upto two level. A binary watermark is embedded in the middle frequency subband and Inverse Discrete Wavelet Transform is performed to obtain watermarked image. To improve the performances, Genetic Algorithm optimization is used to tune the embedding parameter also. Further, GA based WPT is implemented to increase the robustness of the proposed scheme. Quality of the watermarked image is justified through PSNR values. From the results, the PSNR value gets increased in GA based transform when compared to Discrete Wavelet Transform.

To check the robustness of the watermarking scheme, various image processing attacks like Gaussian noise addition**,** Salt & Pepper noise addition, Median filtering, Cropping are implemented on the watermarked image. Result are presented and tabulated. From the results, It is inferred that GA based transform perform better than Digital Image Watermarking.

6. References

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