DWT-SVD Based Digital Image Watermarking Using GA

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Abstract - The objective of the paper is to embed a watermark digital image using discrete wavelet transform. The utmost thrust is to satisfy robustness of watermarked image. For this, singular value decomposition (SVD) method is used. SVD slightly change the singular values of cover image but do not affect the visual perception of the cover image. Genetic algorithm is also used to optimize the result. PSNR and MSE of both watermarked and extracted image is calculated to check the robustness of proposed technique.

Keywords - Digital Watermarking, Robustness, Discrete Wavelet Transform (DWT), Singular Value Decomposition (SVD), Genetic Algorithm(GA).

I. INTRODUCTION

In today's era internet is the big way of communication. Data or important documents are transferred through internet in the form of digital media in large scale. This unrestricted widespread use of Internet and rapid development in multimedia technology has make a common practice to create copy, transmit and distribute digital data. Therefore it may leads to unauthorized replication problem. Digital media requires security of data communication over internet. There are various approaches, which provide security such as, cryptography, steganography and watermarking. In Watermarking, a watermark is inserted in the digital media like image. Digital Image Watermarking provides copyright protection to image by hiding appropriate information in original image to declare rightful ownership [1]. Digital watermarking is a technique in which a piece of digital information is embedded into an image and extracted later for ownership. The watermark embed may be visible or invisible.

The watermark embedding mechanism should meet at least two conditions: imperceptible (the human eyes are not able to distinguish between a watermarked and unwatermarked image) and robust (hard to break). [3]
In this paper, discrete wavelet transform, singular value decomposition and genetic algorithm are used.

II. DIGITAL IMAGE WATERMARKING

Watermarking is the process of embedding the watermark (copyright, message) into digital media. There are two categories of inserting watermark into digital media; Spatial domain and Transform/Frequency domain. In spatial domain the modification would be on the pixels values directly specifically the least significant bit LSB, because it hasn't great effect on the overall pixel value but this technique although it's simple and has less complexity time but it's not robust enough to resist attacks and

ISSN: 2278 – 7798

watermark can easily be detected by intruders. In transform domain the watermark is inserted into transformed coefficients of image giving more information hiding capacity and more robustness.[1]

Discrete wavelet transform

Discrete Wavelet Transform has both frequency and time resolution. The DWT separates an image into a lower resolution approximation image (LL) as well horizontal (HL), vertical (LH) and diagonal (HH). The LL band stands for the coarse one which represents the low frequency part where most energy focuses. The sub-bands labeled HL, LH, and HH represent the details of wavelet coefficients. To obtain the next coarser wavelet coefficients, the sub-band LL is further decomposed as shown in Figure 1. This process can be repeated several times, which is determined by the requirement of user.

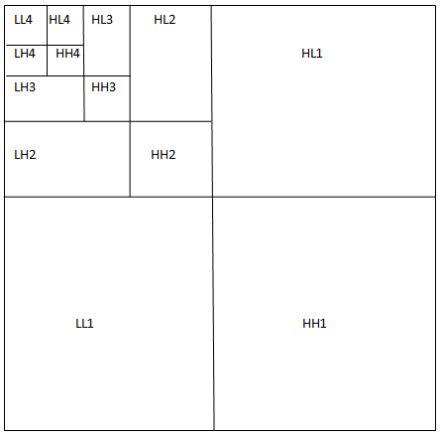


Figure 1: Level 4 DWT

Singular value decomposition

In image processing, an image can be viewed as a matrix with nonnegative scalar entries. The SVD of an image A with size m*m is given by $A=USV^T$, where U and V are orthogonal matrices and $S=diag(\lambda_i)$ is a diagonal matrix of singular value λ_i ,i=1,..m, which are arranged in decreasing order. The columns of U are the left singular vectors, whereas the columns of V are the right singular vectors of image A. SVD is used to find out the singular values of each block of cover image and then modify the singular values to embed the watermark.[2]

Decompose the cover image into four sub bands by four level DWT and apply SVD to intermediate frequency sub bands and then embed the watermark into modified singular values of the cover image to meet the requirement of robustness.[2]

Genetic algorithm

Genetic algorithm is a heuristic search technique for determining the global maximum/minimum solutions for problems in the areas of evolutionary computation.[4]

In digital image watermarking using DWT and SVD, GA initialize the population by choosing a set of random position in the intermediate frequency sub bands of cover image and insert the watermark into selected positions. GA searches its population for the best solution with all possible combinations of DWT sub bands.[5]

III. DWT-SVD-GA Based Watermarking

The proposed scheme uses DWT, SVD and GA techniques. In the given scheme, DWT divides the host image into 4-levels (LL4,HL4,LH4,HH4) and divide the watermark into two parts. Watermark is inserted into intermediate frequency sub bands. One part of watermark is inserted into HL4 sub band and other into LH4 sub band. SVD slightly variates the singular values of the image in HL4 and LH4

ISSN: 2278 – 7798

sub band. GA is applied in embedding and extraction process.

Algorithm 1

I.Watermark embedding

1) Use four level Haar DWT to decompose the host image into four sub bands(i.e. LL4,LH4,HL4 and HH4).

2) Apply SVD to LH4 and HL4 sub bands.

$A^k = U^k S^k V^{kT}$, k=1,2……(1)

Where k represents one of two sub bands.

3)Divide the watermark into two parts $W=W^1+W^2$, W^k represents half of the watermark.

4) Modify the singular values in HL4 and LH4 subbands using SVD.

$S^k + aW^k = U^k{}_W S^k{}_W V^{kT}{}_W$ .....(2)

Where a denotes the scale factor. The scale factor is used to control the strength of the watermark to be inserted.

5) Obtain the two sets of modified DWT coefficients

$A^{*k} = U^k S^k{}_W V^{kT}$, k=1,2 ……(3)

6)Apply genetic algorithm.

7) Obtain the watermark image A_W by performing the inverse DWT using two set s of modified DWT coefficients and two sets of nonmodified DWT coefficients.

9) Calculate MSE by using the formula

$$MSE = \frac{1}{Nt}\sum_{i,j}\left(X(i,j) - X'(i,j)\right)^2|$$

: Original image,

X' : Watermarked image, and

Nt: Size of image

8) Calculate the value of PSNR by using the formula

$$PSNR = 10\,log_{10}\frac{(255 \times 255)}{MSE}$$

II.Watermarking extraction

1)Use four level Haar DWT to decompose the watermarked image image $A^*{}_W$ into four sub bands

2) Apply SVD to LH4 and HL4 subband

$A^{*k} = U^{*k} S^{*k}{}_W V^{*kT}$,k=1,2…….(4)

3) Compute $D^{*k} = U^k S^{*k}{}_W V^{kT}{}_W$,k=1,2

4) Extract watermark from LH4 and HL4 sub band

5)Combine the result

$W^* = W^{*1} + W^{*2}$

6) Calculate PSNR of extracted image.

7) Calculate MSE of extracted image.

Algorithm 2

Genetic algorithm

Genetic algorithm applied in embedding of watermark till to extraction of watermark. Genetic algorithm calculates the number of generations and fitness. Number of generation are calculated in accordance to number of pixels embed and extract into image.

Procedure

Initialize the population and number of iterations.

Generate the first generation of GA individuals based on the parameters specified by performing the watermark embedding procedure. A different watermark image is generated for each individual.

While max iteration do not reached do

- Calculate the PSNR value of watermarked image.
- Calculate the MSE value of watermarked image.
- Calculate the PSNR value of watermarked image.
- Calculate the MSE value of extracted image.
- Calculate the PSNR value of extracted image.
- Select the individual with best fitness value.
- Generate new population.

ISSN: 2278 – 7798

End While.[9]

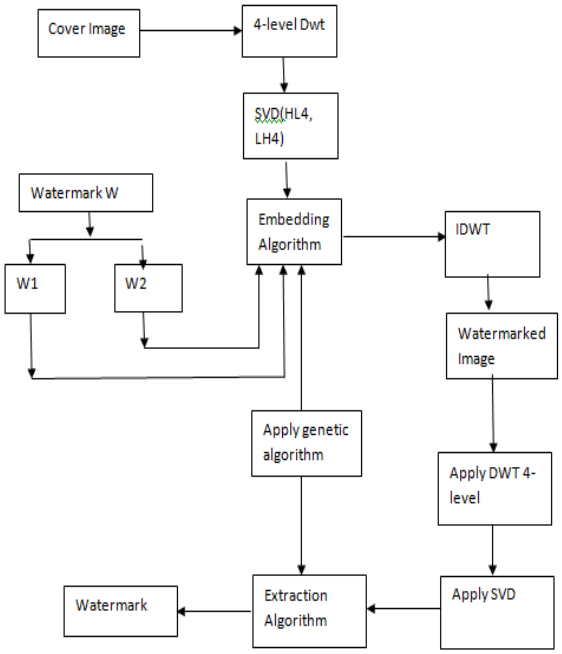
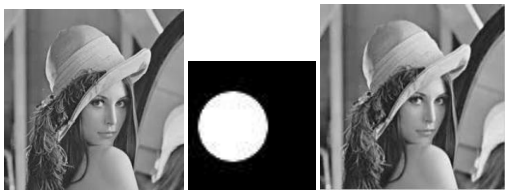


Figure 2. Flow diagram of DWT-SVD-GA

IV. EXPERIMENTAL RESULTS AFTER IMPLEMENTATION

The experiment is implemented in MATLAB 7.10.0.499 by using the standard image lena(256X256) and logo(64X64) as cover and watermark image respectively. DWT, SVD and GA techniques are used. MSE and PSNR values of both watermark and extracted image are calculated.



(a) (b) (c)

Figure3. (a) Cover image, (b) watermark, (c) watermarked

The graph below shows the comparison between SVD-DWT and GA-SVD-DWT techniques, more optimized result is shown using GA.

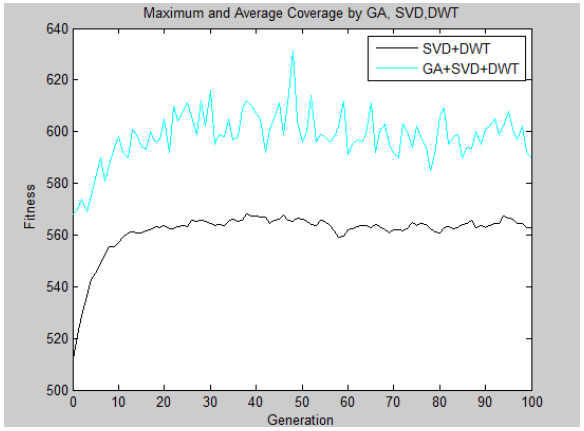


Figure 4. Comparison between SVD-DWT and SVD-DWT-GA

In comparison graph, comparison is based on two parameters fitness and generation. Here, number of generations are taken as 100 and average fitness calculate as 563.010. The above line in the graph shows the results of genetic algorithm, SVD and DWT, and the below line in the graph shows the result of SVD and DWT.

No. of Generations	Average fitness
100	563.010

Table 1. No. of generations & Average fitness

The below table calculate the MSE and PSNR values of embedded and extracted image

MSE of embedded image	PSNR of embedded image	MSR of extracted image	PSNR of extracted Image
2.2363	31.5374	14.3095	17.0283

Table 2. MSE and PSNR values

V. CONCLUSION

In this paper, digital image watermarking based on discrete wavelet transform, singular value decomposition and genetic algorithm techniques are used. Four level DWT is used, Watermark is

ISSN: 2278 – 7798

embed into HL4 and LH4 sub bands and SVD is used to change the singular values of intermediate frequency sub bands and embed watermark into modified singular values of cover image. Genetic algorithm is used to optimize the result. Experiment result shows robustness and calculation of PSNR and MSE of both watermarked and extracted image.

ACKNOWLEDGMENT

The work in this paper has been supported by UGC major project "Development of model for secured communication"

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ISSN: 2278 – 7798

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ISSN: 2278 – 7798