A Novel Method based on Integer Wavelet Transform and Genetic Algorithm for Steganography

Mr. P.Natraju
Tenali Engineering College

Mr. D. Suneel
Nalanda Institute of Engg. & Tech.

Ms. V. Siva Madhuri
Tenali engineering college

Mr G. Vijaya Krishna
Tenali engineering college

Abstract--- ***The proposed system presents a novel approach of building a secure data hiding technique of steganography using integer wavelet transform along with Genetic algorithm. The novel scheme embeds data in integer wavelet transform coefficients by using a mapping function based on Genetic Algorithm in an 8x8 block on the cover image. The optimal pixel adjustment process is applied after embedding the message. We employed frequency domain to increase the robustness of our steganography method. Integer wavelet transform avoids the floating point precision problems of the wavelet filter. We use GA and Optimal Pixel Adjustment Process to obtain an optimal mapping function to reduce the difference error between the cover and the stego-image and to increase the hiding capacity with low distortions respectively. Simulation results show that the novel scheme outperforms adaptive Steganography technique based on integer wavelet transform in term of peak signal to noise ratio and capacity.***

Keywords---Steganography,IntegeWaveletTransform, Genetic Algorithm, Optimal Pixel Adjustment Process, Peak Signal to Noise Ratio.

I. INTRODUCTION

Steganography is the art of hiding secret information in the form of cover which can be image [1], complex audio[2], video or any sophisticated biometrics formats [3]. Clearly, the goal of cryptography is to protect the content of messages [4], steganography is to hide the existence of Messages. An advantage of steganography is that it can be employed to secretly transmit messages without the fact of the transmission being discovered. Generically, the steganography process is classified into two phases in majority of the prior research work e.g. message embedding and extraction. In the embedding operation, a secret message is transformed into a bit stream of bits, which is embedded into the least significant bits (LSBs) [5] of the image pixels. The embedding overwrites the pixel LSB with the message bit if the pixel LSB and message bit do not match. Otherwise, no changes are necessary. For the extraction operation, message bits are retrieved from pixel LSBs and combined to form the secret message. There are two main selection algorithms that can be employed to embed secret message bits: sequential and random. For sequential selection, the locations of pixels used for embedding are selected sequentially one after another. For instance, pixels are selected from left to right and top to bottom until all message bits are embedded. With random selection, the locations of the pixels used for embedding are permuted and distributed over the whole image. The distribution of the message bits is controlled by a pseudorandom number generator whose seed is a secret shared by the sender and the receiver. This seed is also called the stego-key. The latter selection method provides better security than the former because random selection scatters the image distortion over the whole image, which makes it less perceptible. In addition, the complexity of tracing the selection path for an adversary is increased when random selection is applied. Apart from this, steganographic security can be enhanced by encrypting the secret message before embedding it. Whereas the proposed work has considered exclusive gray image from standard image datasets of “Lena”, “Boat”, section 1 we give an overview of related work which identifies all the major research work being done in this area. Section 2 highlights about the proposed system along with system architecture and algorithm description. Implementation and result analysis is discussed Section 3 followed by conclusion in Section -4.

II. PROPOSED METHOD

The main purpose of the project work is to novel stegano algorithm along with implementation of Genetic algorithm and Integer Wavelet Transform to ensure image security and maintain image quality. The proposed method embeds the message in Discrete Wavelet Transform coefficients based on genetic algorithm and optimal pixel adjustment process algorithm and then applied on the obtained embedded image. The system architecture of the proposed work is as shown in fig. 1 below.

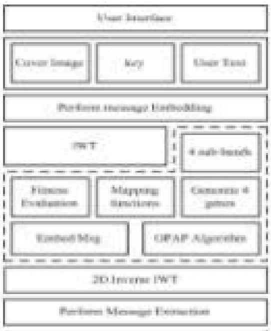


Fig. 1. Proposed System Architecture

As already known, the wavelet transform has the potential to present some information on frequency-time domain simultaneously, where Haar wavelet operates on data by calculating the sums and differences of adjacent elements. This wavelet operates first on adjacent horizontal elements and then on adjacent vertical elements. One nice feature of the Haar wavelet transform is that the transform is equal to its inverse. Each transform computes the data energy in relocated to the top left hand corner. The proposed algorithm employs the wavelet transform coefficients to embed messages into four sub bands of two dimensional wavelet transform. To avoid problems with floating point precision of the wavelet filters, the proposed system uses Integer Wavelet Transform. This paper embeds the message inside the cover with the least distortion therefore we have to use a mapping function to LSBs of the cover image according to the content of the message. The proposed system also use Genetic Algorithm to find a mapping function for all the image blocks, where various block based techniques can be used to retain local image property and minimize the algorithm complexity compared to single pixel substitution.

III. THE STEGANOGRAPHY METHOD

In the proposed method, the message is embedded on Integer Wavelet Transform coefficients based on Genetic Algorithm. Then, OPAP algorithm is applied on the obtained embedded image. This section describes this method, and the embedding and extracting algorithms in detail.

A. Integer Wavelet Transform

The proposed algorithm employs the wavelet transform coefficients to embed messages into four sub bands of two dimensional wavelet transform. To avoid problems with floating point precision of the wavelet filters, we used Integer Wavelet Transform. The LL sub band in the case of IWT appears to be a close copy with smaller scale of the original image while in the case of DWT the resulting LL sub band is distorted [9] as shown in "Fig.1

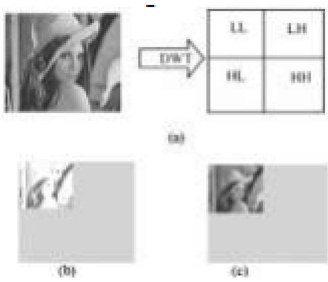


Fig. 2. (a) Original image Lena and how to analyze in wavelet domain. (b) One level 2DDWT in sub band LL (c) One level 2DIWT in sub band LL.

Lifting Scheme is one of the techniques on integer wavelet transform. The decomposing filter in integer wavelet Transform can be calculated according to [13]:

$$s_{1,k} = \left\lfloor (s_{0,2k} + s_{0,2k+1})/2 \right\rfloor$$

$$d_{1,k} = s_{0,2k+1} - s_{0,2k} \qquad (1)$$

Then the inverse transform can be calculated by:

$$s_{0,2l} = s_{1,l} - \left\lfloor d_{1,l}/2 \right\rfloor$$

$$s_{0,2l+1} = s_{1,l} + \left\lfloor (d_{1,l}+1)/2 \right\rfloor \qquad 2)$$

These equations should be in 2D in order to be applied on images. Simple 2D transform has employed in this paper and it can be computed for an image according to [14]:

$$A_{i,j} = \left\lfloor (I_{2i,2j} + I_{2i+1,2j})/2 \right\rfloor$$
$$H_{i,j} = I_{2i,2j+1} - I_{2i,2j}$$
$$V_{i,j} = I_{2i+1,2j} - I_{2i,2j}$$
$$D_{i,j} = I_{2i+1,2j+1} - I_{2i,2j} \qquad (3)$$

B. Genetic Algorithm

This paper embeds the message inside the cover with the least distortion therefore we have to use a mapping function to LSBs of the cover image according to the content of the message. We use Genetic Algorithm to find a mapping function for all the image blocks. Block based strategy can preserve local image property and reduce the algorithm Complexity compared to single pixel substitution.

C. • Chromosome Design

In our GA method, a chromosome is encoded as an array of 64 genes containing permutations 1 to 64 that point to pixel Numbers in each block. Each chromosome produces a mapping function as shown in fig 3.

60	7	24	....	52	3

Figure 3 A simple chromosome with 64 genes

D. • GA Operations

Mating and mutation functions are applied on each chromosome. The mutation process causes the inversion of some bits and produces some new chromosomes, then, we select elitism which means the best chromosome Will survive and be passed to the next generation.

E. • Fitness function

Selecting the fitness function is one of the most important steps in designing a GA-based method. Where a sour GA aims to improve the image quality, Pick Signal to Noise Ratio (PSNR) can be an appropriate evaluation test. Thus the Definition of fitness function will be:

$$PSNR = 10\log_{10}\frac{M\times N\times 255^2}{\sum_{i,j}(y_{i,j}-x_{i,j})^2} \quad (4)$$

Where M and N are the image sizes and, x and y are the image intensity values before and after embedding. Message embedding scheme The frequency domain representation of the respective created blocks is projected by two dimensional Integer wavelet transform in order to accomplish 4 sub bands LL1,HL1, LH1, and HH1, where 64 genes are generated containing the pixels numbers of each 8x8 blocks as the mapping function. The message bits in 4-LSBs IWT coefficients each pixel according to mapping function are embedded. Based on fitness evaluation, Optimal Pixel Adjustment Process on the Image is applied. Finally, inverse two dimensional integer wavelet transform is computed in this module in order to generate the stego image. Input: The input for this processing is basically a user text message and cover image for embedding purpose. Output: Generation of stego image Inter component Relationship: This module interacts with all the components of the application responsible for selection of parameters for performing encryption. Algorithm descriptions are as follows:

Algorithm: Message Embedding
Input: Colored Image, User Plain Text, key
Output: Stego-Image
Steps:
1. Perform Integer wavelet transform using lifting scheme
2. Start from the Haar wavelet and get the corresponding
   lifting scheme
3. Add primal ELS to the lifting scheme.
4. Perform integer LWT of the same image.
5. Divide image in 8 x 8 blocks and perform IWT on each
   block
6. Find the frequency domain representation of blocks by 2D
   Integer Wavelet Transform
7. Obtain the size of an image.
8. Generate 64 genes containing the pixels numbers of each
   8x8 blocks as the mapping function
9. Initialize empty matrix to store the wavelet values
10. Obtain 8 x 8 blocks for R G B
11. Perform IWT
12. Concatenate all coefficients together
13. Store the coefficient in new image
14. Embed in 4-LSBs IWT coefficients each pixel according
   to mapping function
15. Save the transformed image
16. Fitness evaluation is performed to select the best mapping
   function
17. Calculate embedded capacity
18. Apply Optimal Pixel Adjustment Process on the image.
19. Convert image to binary
20. Calculate inverse 2D-IWT on each 8x8 block.

Algorithm: Message Extraction
Input: Stego-Image, key
Output: Original Secret Message
Steps:
1. Divide the cover image into 8x8 blocks
2. Extract the transform domain coefficient by each 8x8 block.
3. Employ the obtained mapping function in the phase
4. Find the pixel sequences for extracting.
5. Extract 4-LSBs in each pixel.

F. OPAP algorithm

The main idea of applying OPAP is to minimize the error between the cover and the stego image. If the pixel number of the cover is 10000 (decimal num the message vector for 4 bits is 1111, then the will change to 11111 (decimal number 31)and the error will be IS, while after applying OPAP algorithm bit will be changed from 1 to 0, and the embedding error is reduced to 1.

Algorithm: Minimizing R- blocks using Genetic Algorithm
Input: Stego-Image, Alpha value
Output: Minimization of R- block
Steps:
1. Perform Chromosome Initialization Steps.
2. Select every 3 adjacent pixels in the block
3. Initialize maximum Fitness as 0
4. Initialize Alpha as 0.88
   //The factor alpha is used to control the weights of the visual quality of the steg-image and the secrecy of the embedded message.
5. Flip second lowest bit randomly for number of time
6. For kk = 1: length (Block)-2
7. Chrom = Block (kk: kk+2);
8. Cp = non_negative_flipping(Chrom);
9. Cn = non_positive_flipping(Chrom);
10. Initialize e1 and e2 as 0

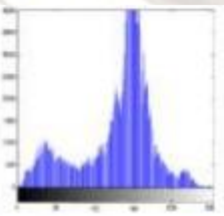
11. Compute Correlation (C, Cn, and Cp)
12. If Cn<C
13. e1 = 1;
14. End
15. If Cp> C
16. e2 = 1;
18. Apply PSNR = SNR (Chrom-Cn); // See Line-7
19. Apply FITNESS = alpha*(e1+e2)+PSNR
20. If fitness>maxfitness
21. maxfitness = fitness;
22. Chrommax = Cp;
23. Crossover = crossover+1;
24. End
25. Replace chromosome with new one
26. Compute pns and pnr
27. If Pns>Pnr//See line-15-16 of previous algorithm
28. Block is successfully adjusted
29. End
30. Compute difference, diff1 = Ppr-Pnr
31. Compute difference, diff2 = Pps – Pns

IV. IMPLEMENTATION AND RESULT ANALYSIS

The proposed method is applied on SI2xSI2 8-bitgrayscale images "Blue hill" and "Lena". The simulation is implemented on 2.SGHZ Core 2 Duo processor, 4GBRAM and Windows Vista OS and Matlab7.6. The messages are generated randomly with the same length as the maximum hiding capacity. Table shows the stego image quality by PSNR as described in Eq. (4). Human visual system is unable to distinguish the grayscale images with PSNR more than 3S dB.

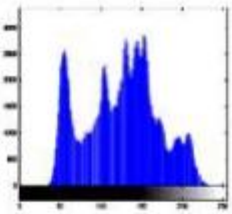
Cover image	Method	Max.H.C. (bits)	Max.H.C (bits)	PSNR (db)
Lena	Proposed method	1048576	50%	35.17
	Adaptive steganographic based IWT	986408	47%	31.8
Jet	Proposed method	1048576	50%	45.20
	Adaptive steganographic based IWT	986406	46%	31.6

g) Boat Cover image



b) Boat Histogram

a) Lena Cover image



b) Lena Histogram

V. CONCLUSIONS

This paper presented a novel technique to increase the capacity and the imperceptibility of the image after embedding. GA is employed to obtain an optimal mapping function to reduce the error difference between the cover and the stego image and use the block mapping method to preserve local image properties and to reduce the algorithm complexity, and then applied the Optimal Pixel Adjustment Process to increase the hiding capacity of the algorithm in comparison to other systems. The drawback of this method is the execution time that can be the subject of our future studies to select the best block size to reduce the computation cost and to increase the PSNR using optimization algorithms such as genetic Algorithm.

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