Hight Capacity and Optimized Image Steganography Technique based on Ant Colony Optimization Algorithm

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***Abstract*— The tremendous development of digital technology, it is mandatory to address the security while transmitting information over network in a way that observer couldn't depict it. Measures to be taken to provide the security by establishing hidden communication using steganography principle which is help to camouflage the secret information in some carrier file such as text, image, audio and video. In this era of hidden data communication, image becoming an effective tool on account of their frequency, capability and accuracy. Image steganography uses an image as a carrier medium to hide the secret data. The main motive of this article is that the uses the combination of frequency domain and optimization method inorder to increasing in robustness. In this article, Integer Wavelet transform is performed into the host image and coefficients have been transformed. ACO optimization algorithm is used to find the optimal coefficients where to hide the data. Furthermore, sample images and information having been demonstrated which proved the increased robustness as well as high level of data embedding capacity.**

***Keywords*— Security; Image, Steganography; IWT; Ant Colony Optimization algorithm;**

I. INTRODUCTION

Steganography is the art and science of secret communication between two parties over a public medium that is not detectable by an observer. Steganography is a close cousin of cryptography which is the art and science of secret communication. Cryptography aims to conceal the content of the message whereas steganography hides the very existence of secretive communication as well [1]. For example, two users want to sharing information between them. But noticer is examining that communication via Internet Service Provider or local server. To protect this communication, steganography provide a model in which sender A wish to send message M to receiver B. Sender embed M over the cover media C and obtained stego object S then sent it over the insecure channel. The terms cover object is defined as various types of multimedia objects are used to hide the data and stego object is known as which object embedded the secret information[5].

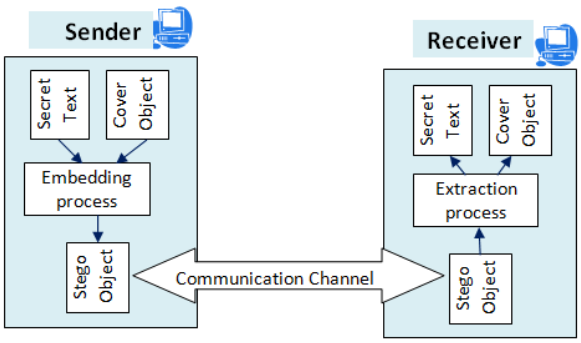

Fig. 1. Example of a figure caption.

Effective characteristics of steganography[8];

1. Secrecy : With the allowing of intend users, extracting the hidden information
2. Imperceptions: The ability to be completely undetectable
3. Capacity: Maximum length of the hidden information which can be embedded in cover object.
4. Accuracy: Extracting of the embedded data should be accurate.

Steganography techniques are classified into two types which are spatial domain and frequency domain techniques. In spatial domain, processing is data hidden directly on the pixel values of the image and in frequency domain, image is transformed then data is hidden on the transformed coefficients [6]. Some of the spatial domain techniques are LSB, PVD, EBE, RPE, PMM and Pixel intensity based etc. and some of the frequency domain techniques are DCT, DWT, DFT, IWT and DCVT [5]. Specifically, spatial domain techniques are susceptible to visual attack and pixel alteration [9]. When comparing to spatial domain, transform domain techniques are more robustness because of its hiding scheme in significant areas of cover images [10, 11]. Integer wavelet

transform (IWT) maps an integer data set into another integer data set. In discrete wavelet transform, the used wavelet filters have floating point coefficients so that when we hide data in their coefficients any truncations of the floating point values of the pixels that should be integers may cause the loss of the hidden information which may lead to the failure of the data hiding system [7].

The remaining of the paper is constructed as below: Relevant works have discussed in section 2. In section 3, explain the workflow of proposed method include algorithms. In Section 4, prove the proposed method has increasing in robust and level of capacity by carried out the experiment on sample image and secret data. Finally, Section 5 concludes the article.

II. Related Work

Discrete Wavelet Transforms are used in JPEG2000 image format and several methods embed information using Integer Wavelet Transform Coefficients. Lai and Chang proposed an adaptive data hiding method in the frequency domain [2].

Seyyedi et al. in [3] proposed a high volume payload and secure steganography technique based on integer wavelet transform. Ghasemiet al. combined Genetic Algorithm (GA), OPAP and Integer Wavelet Transforms to reduce distortion while delivering high embedding capacity in [4].

N. Vinothkumar et al. [13] have been suggested to embed the data over image on the basis of the combination IWT with Optimal pixel Adjustment Process (OPAP). The method use IWT to transform the coefficients on cover image and OPAP is used to raise the level of hiding capacity. Result shows that minimize difference error betwixt original and encoded image.

Ching-Sheng Hsu et al. [14] have been proposed method to determined the optimal LSB substitution using ACO algorithm . This method embeds the data into the last bits of the cover image. Moreover, generate optimal matrix with the help of ACO algorithm to conceal the data at the optimal values.

Rafael Lima de Carvalho et al. [15] have been used optimization principle to hide the secret message into the target picture. Optimization done by PSO algorithm and produce better result than classical GA based method.

Amanjot Kaur et al. [16] have been proposed algorithm which finding an optimal block on image may be the best position to hide the data. The fitness function to be taken where ratio is maximize of sum of contrast and energy and entropy and homogeneity. Results prove that this algorithm showing superiority than PSO algorithm.

III. Proposed Method

The proposed method is splitted into two subsequent parts such as using IWT for transforming coefficients and ACO to find the best values for embedding. In the first part of proposed method, input the color image as carrier and extracting three RGB color components [17]. Integer wavelet transform is applied on these components and results showing transformed coefficients. Second part concerned the Ant Colony Optimization algorithm which inspired the behavior of ants. These ants deposited pheromone on the path to discover shortest best path from nest to food. More pheromone on path increases, that path followed by every other ants of the colony. Ant Colony Optimization Algorithm work on the basis of the similar mechanism and used in proposed method. The secret raw data has been converted into ASCII values and these can be embedding at the optimal coefficients by applying ACO algorithm. After all secret values were embedded; inverse IWT is processed to gain the stego object and ready to send it to receiver. At the recipient side, received it and extract the secret data from it by performing the reverse procedure of embedding method. With the neat sketch, the entire work of proposed method is described in the following figure.

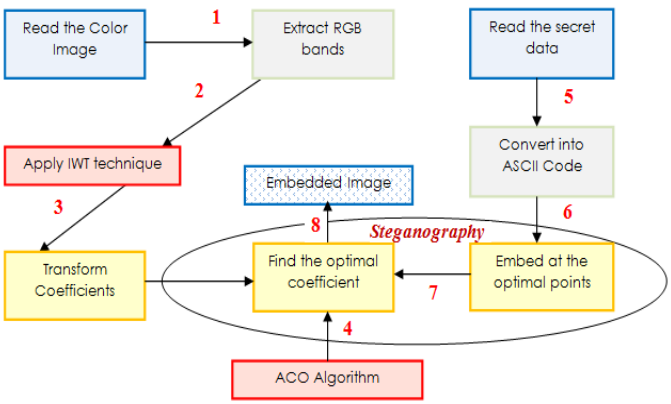

Fig. 2. Flow chart for the proposed algorithm

A. Ant Colony Optimization Algorithm

In computer science and operations research, the ant colony optimization algorithm (ACO) is a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs [18]. The ACO algorithm is one of the most competent methods that indicate the main aspects of state transition rules and pheromone modernize devices. In each iteration, colonies of ants are sent to a particular place for solution. Each ant works steadily in their state transition rules. Suppose, if an ant

completes a work, then the pheromone modernized begins to search another ant with similar strength. But it significantly reduces the opportunities and changes the search methodology.

Step 1: Initialize the solution H_i

Step 2: Find the fitness value (F_i)

Step 3: Based on the fitness find Probability transition matrix.

$$P_{ij}^{\ c} = \frac{(\tau_{ij})^{\alpha}(\eta_{ij})^{\beta}}{\sum(\tau_{ij})^{\alpha}(\eta_{ij})^{\beta}}$$

Step 4: Update pheromone and Evaporation pheromone.

$$\tau_{ij} = (1-\rho) * \tau_{ij} + \sum_{C=1}^{S} \Delta\tau_{ij}^{\ C}$$

Step 5: Find the fitness for H_{new} from pheromone evaporation

$$if\,(H_{new}) > f(H_i)$$

Step 6: Store the best solution so far attained

Iteration=Iteration+1

Step 7: Stop until optimal key attained

Where,

ρ = pheromone evaporation rate

S = number of ants

$\Delta\tau_{ij}^{\ c}$ = is the quantity of pheromone laid on edge (i,j) by c^{th} ant

B. Proposed Algorithm

Proposed embedding algorithm is enumerated below to hide the data over the cover image.

Step 1: Given input as color image and secret data.

Step 2: Extract RGB components from color image.

Step 3: IWT technique is applied on the bands and makes transformation among the coefficients.

Step 4: ACO algorithm is used to find the optimal points.

Step 5: Data is converting into ASCII values. On each row at every location given by the ACO, embed values at those optimal points.

Step 6: Finally, stego image is obtained by process the inverse IWT method.

Whereas the proposed extracting algorithm is explained below;

Step 1: Receive the stego image

Step 2: Data is extracting from the stego image by performing the reverse operation of embedding method.

Step 3: Obtained the secret data.

IV. Results and Discussion

Our proposed approach has been validated by experimenting with variations of the images. The proposed system has been implemented in Visual Studio 2010, with .NET Framework Version 4.0 using the language of C# windows application. The experiment has been conducted several test images by taking RGB cover images of dimension 512x512. Figure 3 shows the original images, secret data and stego images. From the experimental results, we can observe that after secret data embedded, there is no visual difference from the original image. Hence, the existence of the embedded message will not be known to the unauthorized users.

For comparing stego image with cover results requires a measure of image quality, commonly used measures Peak Signal-to-Noise Ratio [12]. If SNR and PSNR represent smaller value, then it indicates there is a large between the original (without noise) and distorted image. The main advantage of this measure is ease of computation, but it does not reflect perceptual quality. An important property of PSNR is that a slight spatial shift of an image can cause a large numerical distortion but, there would be no visual distortion and conversely, a small average distortion can result in a damaging visual artifact, if all the error is concentrated in a small important region [19,21].

Information hiding has attracted lots of attention over recent years. It is the art and technique of concealing a message in a cover without leaving any remarkable trace on the cover signal. There are three main compromising attributes for a data hiding system, known as capacity, imperceptibility, and robustness. The data hiding schemes are principally categorized into steganography and watermarking, according to the application based requirements. In the steganography systems, our goal is to provide more capacity, where a better robustness characteristic is of concern in watermarking

(a) Original Image (b) Sample Secret Data

(c) Stego Image

Fig. 3. Experimental results of the proposed technique

The proposed technique with their PSNR is employed for various sample test images. PSNR values with original image and decrypted image, the value should be higher, it denotes the better for its superiority. PSNR value of the proposed method is 40.83 for the above test image. It represents better image quality with high capacity of the cover image.

V. CONCLUSION

This paper presents a high capacity and optimized image steganography technique based on ant colony optimization algorithm. Here we have used a concept of stegnography technique with optimization techniques to improve the capacity with high security. The ACO algorithm can find good solutions efficiently even though the search space is so large. Also experimental results provide acceptable image quality of the stego images in terms of (PSNR) is very efficient. In future, some data encryption technique can be applied along with other optimization algorithm to increase the security level.

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