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Developing The PSO Algorithm For Hiding a Secret Information In Color Image Using LSB Technique

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Abstract**—**Generally, The sending process of secret information via the transmission channel or any carrier medium is not secured. For this reason, the techniques of information hiding are needed. Therefore, steganography must take place before transmission. To embed a secret message at an optimal positions of the cover image, using the developed particle swarm optimization algorithm (Dev.-PSO) to do that purpose in this paper. The main aim of (Dev.-PSO) algorithm is determining an optimal paths to reach a required goals in the specified search space based on disposal of them, using (Dev.-PSO) algorithm produces the paths of a required goals with most efficient and speed. an agents population is used in determining process of a required goals at search space for solving of problem. The (Dev.-PSO) algorithm is applied to different images, the number of an images which used in the experiments in this paper is three. For all used images, the PSNR value is computed. Finally, the PSNR value of the first stego-image is equal (80.74), while the second stego-image is equal (80.01), and the PSNR value for the third stego-image is (81.5). Generally, the results of paper experiments are good.

Index Terms— steganography, developed PSO algorithm, cover image, stego image, search space and PSNR.

I. INTRODUCTION

The most important concept in any communication process between sender and receiver via the transmission channel is security. Using the advance technology and the world wide web to exchange information leads to increase the challenges and risks. However, the management of challenges and risks is possible with using an advanced technologies of secure networks but these technologies are not enough for information security over communication between sender and receiver. Therefore, an additional mechanisms of security are needed to secure information. [1], an origin of steganography word is Greek, steganography means "covered writing" or "concealed writing"[2]. The main difference between steganography and cryptography is keeping the existence of a message secret. The shared goal of steganography and cryptography is information protecting against malicious or unwanted persons or parties [3].

II. STEGANOGHRAPHY

An embedding algorithm embeds a secret information in a host image, the hiding process is performed with selected private or secret key to increase the complexity of hiding process. A generic model of an image steganographic is shown in figure (1). After embedding process, transmitting a stego-image to the receiver via transmission medium or communication channel is performed. The receiver extracts a hidden information which embedded using embedding technique by the sender from received stego-image with using same or another key according to type of steganography that selected initially. The receiver will apply an extraction technique on stego-image for that purpose. Via transmitting a stego-image from the sender to the receiver, there are many unauthorized persons or parties that notice a stego-image but without extracting the hidden contents of a stego-image[4]. The embedding techniques are selected according to type of domain, the types of embedding domains are spatial and frequency domains. The types of host or cover are text, audio, image and video[5]. The spatial domain is used in this work. In the spatial domain, the secret message is embedded in the specified positions by adding or replacing the bits of selected bits of cover or host image. Generally, the typical characteristics of spatial domain are all methods related to this domain are very easy and simple to understand, the execution time is low, a secret message is applied to the pixels directly without transforming an original image and finally a secret message is embedded in the region or part of host or cover image that considered as redundant[6]. There are many techniques related to the spatial domain of an image steganography such as Least Significant Bit (LSB) and Most Significant Bit (MSB) techniques. The LSB technique is used in this work. This technique embeds a secret information in the least significant bit of selected pixels of the host image. So, It exploits the point which the precision in several image formats is greater than the human vision. The variations of image colors are indistinguishable by human vision [7].

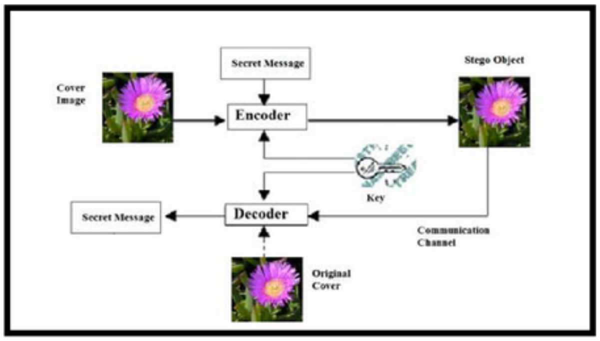


Fig. 1. Basic steganography model.

III. PSO ALGORITHM

In 1995, by Kennedy and Eberhart, The PSO was introduced [8]. The model of PSO consists of many particles for swarm, in the beginning, the random candidate solutions population is initialized. for searching a new solutions, They must move in an iterative manner via the d-dimensions search space of problem when the fitness function (f) can computed as metric or measure for quality assessment. the position-vector xi (where i is an index for particle) is used to represent a positions since each particle has a position. The velocity-vector vi is used to represent a velocity. For each one of particle, the best position is remembered by them. a vector i-th, with its d-dimensional value is represented as pbest(pid). The best position-vector is stored in a vector i-th, and its d-th dimensional value which is represented as gbest(pgd). t represents time iteration equation (1) is used to determine the updating or modifying the velocity (vid) from the old velocity to the new. The sum operation of the previous position and the new velocity is used to specify a new position (xid) as shown below in equation (2).

$$V(id+1) = w * vid + c1 * r1 * (pgd - xid) + c2 * r2 * (pid - xid) \ldots \quad (1)$$

$$X(id+1) = xid + v(id+1) \ldots \quad (2)$$

Where i from 1 to N; an inertia weight is described as w, r1 and r2 are considered as random numbers, to maintain the diversity of the population, these are used. These numbers are distributed in the interval [0,1] of the d-th dimension for the i-th particle. c1 acts a positive constant number, this constant is called coefficient of the self-recognition component; c2 represents a positive constant number, this constant is called coefficient of the social component. From equation(2), a particle decides where to move from current position to next position, with its experience, it saves the memory of the best past position, and the most successful particle. to lead the particles in the search space effectively, during one iteration, the maximum moving distance must in between the maximum velocity [−vmax,vmax]. The steps of standard PSO algorithm are shown in algorithm (1)[9]:

Algorithm (1): The standard PSO alg.

I/P: Parameters initialization (c1,c2,w,vmax,Swarm_Size, Max_Iter,r1,r2).

O/P: highest fitness optimization

Step 1: Generating initial particles and velocities randomly

Step 2: For each particles, the fitness function is calculated .

Step 3: If new position is better than old position then updating process is performed.

Step 4: Specify the best particle and update the positions using equations (1) and (2).

Step 5: If the high fitness is satisfied or maximum number of iterations has exceeded then go to 6 else go to 2.

Step 6: the best value is Stored then exit.

IV. APPLY DEVELOPED PSO ALGORITHM TO FIND THE BEST LOCATIONS

Using the developed PSO algorithm in this work aims to secure transmitted information that sent by sender via insecure communication channel to the receiver. The important aim of the proposed system is to provide secure communication between sender and receiver. So, an optimal positions in the search space of problem are determined by using developed PSO algorithm to embed a secret message in the host or cover image. After determining an optimal solutions in the host or cover image by this developed algorithm, where starting point of particle did not specify in the PSO algorithm, a particle sometime put in center of the image or put randomly in any position of the search space. The new of developed PSO is to find the starting point. the host or cover image is divided into five parts as following sequence (upper right part, upper left part, lower left part, , lower right part and center of image part). The standard PSO algorithm as shown above in algorithm (1) is performed in parallel manner on those five parts. for all locations in the image, the fitness function is computed through applying some steps of statistical calculations such as X-position, Y-position, Mean and Variance. the 2D-dimensional locations can denoted by X-position and Y-position for the coefficients in the image. for each specified positions, The mean is computed by applying equation (3) while the variance is calculated by applying equation (4) as shown below.

$$\text{Mean}(i) = \left(\sum_{j=1}^{M} Xi(j) \right) / M \ldots \quad (3)$$

$$\text{Variance}(i) = \left(\sum_{j=1}^{M} (Xi(j) - \text{mean}(i))^2 \right) / M \ldots \quad (4)$$

where: xi(j) is the datum in specific position, and M is the number of locations.

All information that related for each bird or particle are shown as following:

1- The current position fitness of the bird or particle is denoted by f(x).
2- For each position in the search space, the best fitness is denoted by f(gbest).
3- The neighbors f(x) best fitness is denoted by f(xbest).
4- The current position of the fitness bird or particle is denoted by Lx .
5- the best fitness position in the search space is denoted by Lgbest .
6- The best fitness position of the neighbor f(x) is denoted by Lxbest.
7- The cognitive and social parameters are called acceleration parameters that bounded between 0 and 2, these parameters are denoted by α , β.
8- The random numbers distributed in [0, 1] are denoted by rand1& rand2.
9- The maximum number of iteration is denoted by D.

Each particle moves in the multi-dimensional solutions space with different speeds, therefore, its velocity or speed is according to their moving. For each position, saving information of its previous movement in the problem space is recorded. the movement of particle is influenced by just two factors, the first factor is the local best solution and the second factor is the global best solution. a particle updates its velocity and position if it can specifying a best location that considered as better than others locations which visited previously. The velocity and position updating process is performed using equation (5) and equation(6) respectively.

$$fi(t+1)= f(x) + \alpha \ rand1 \ (Lgbest - Lx) + \beta \ rand2 \ (Lxbest - Lx) \quad \ldots\ldots(5)$$

$$Lxi(t+1)=Lx+fi(t+1) \quad \ldots\ldots(6)$$

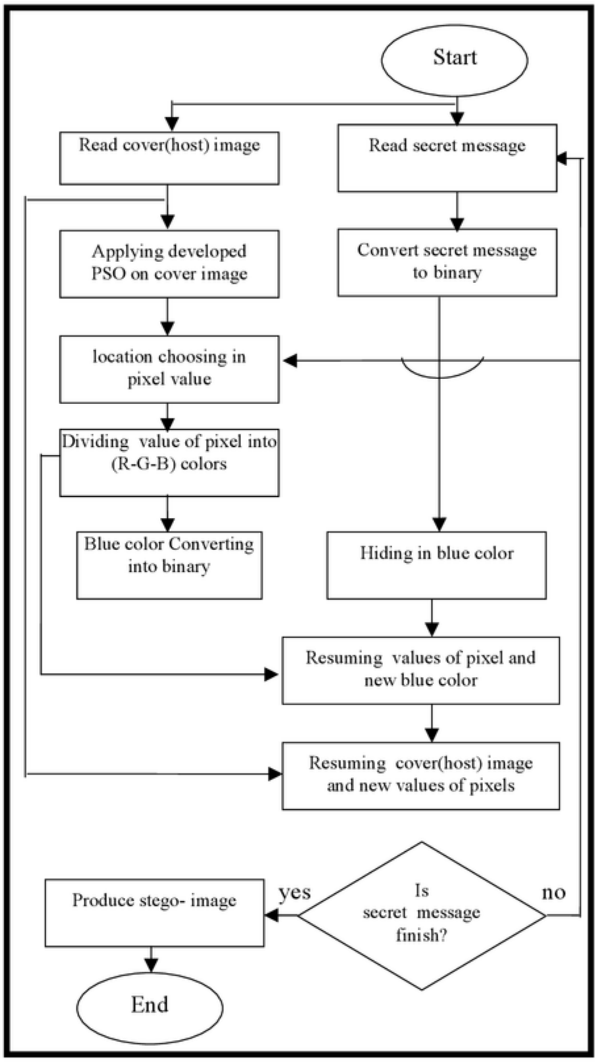
With each iteration, The global best location (gbest) is compared to the five parts. the location acts the best starting point of selected locations when the gbest is equaled. This is considered as the start point of the PSO search space which produces the best locations or positions. The developed PSO algorithm for finding best position is shown in algorithm (2). for an iteration process of the algorithm, if better solution is satisfied, then the global best position and the best local position are modified or updated. This process is continuous until the determined number of iterations is exhausted. In this work, The number of iterations is 500 iteration[8].

Input : 128*128 cover image , parameters α , β,rand1, rand2, max iteration D, variable W, best location xx,(L1,L2,L3,L4,L5)=particles
Output : Selected locations
Begin
Step 1: Set D=1 , W=0
Step 2 : position fitness is computed using Eq. 3 and Eq.4
Step 3 : For the selected image do the following
a- Divided the image region into five section
b- Specify the center of each section
c- Initialize the five particle position and velocities in center of each section
d-Determine the fitness of gbest for each particle
e-Choose the best of them
f- Optimize (evaluate fitness) to the better
g- If the particle fitness f (x) < particle best fitness f(xbest)
Then f(xbest) = f(x) and Lxbest =Lx
h- if f(x) < f(gbest) Then f(gbest) = f(x) and L(gbest) =Lx
i- Update
particle velocity using Eq. (5)
particle position using Eq. (6)
j- If L1(gbest) = L2(gbest)= L3(gbest)= L4(gbest)= L5(gbest)
Then Stop the iteration
xx= L1(gbest) = L2(gbest)= L3(gbest)= L4(gbest)= L5(gbest)
Else
Combine any equal of (L1(gbest) , L2(gbest), L3(gbest), L4(gbest), L5(gbest)) go to step 3(d)
Step4 : Set D=1 , W=0
Step 5 : Calculate the fitness according to Eq. (3) and Eq.(4) of the image
Step 6 : Initialize the particle position and velocities in (xx)of the image
Step 7: optimize (evaluate fitness) of the image
If particle fitness f (x) < particle best fitness f(xbest)
Then f(xbest) = f(x) and Lxbest =Lx
Step 8 : optimize 2 (evaluate fitness) of image
if f(x) < f(gbest) Then f(gbest) = f(x) and Lgbest =Lx
Step 9 : Adjustment process
Velocity of particle by Eq.(5)
Position of particle by Eq.(6)
Step 10: List= value (best), D=D+1
Step 11 : if (D < = 500) Then Repeat from step (7)
Terminate
End

Algorithm (2): Developed PSO algorithm

V. Steganography Using Developed PSO Algorithm

After a secret message selecting, it must converted into binary form, the number of secret message bits is equal to 500 bit. We select an image with size 128x128 pixel, then apply the developed PSO algorithm to select the best 500 location of selected image above. The values of the best 500 location are divided into three main parts, each part of them represents a color such as part1 of values represents Red color , part2 of values represents Green color and finally part3 of values represents Blue color. After that all values are converted inti binary form. In hiding process, we hide one bit from a secret message in the least significant bit of the blue color that selected to hide information in it. The embedding process is shown below in figure (2).



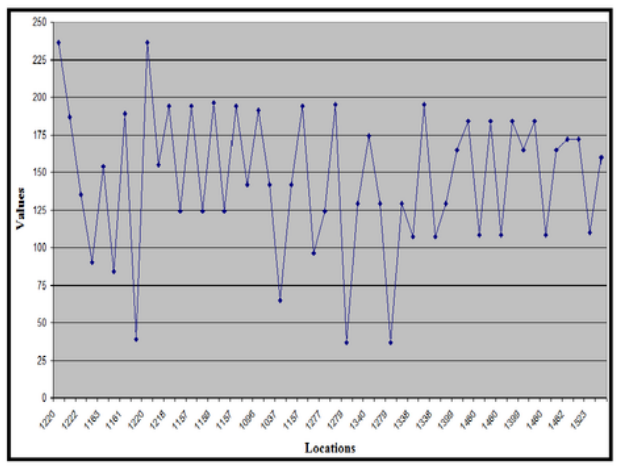
Figure(2): Flowchart of embedding process using Dev- PSO

VI. Results of Performance

In this section, the results of applying the developed PSO algorithm to determine an optimal solutions in search space of problem are shown. The value that determined by five particles and the best location in each one of selected image are shown in Table (1).

Table (1): Values and locations of finding optimal starting location for Dev. PSO

First section						
PSO Number	Location of First iteration	value	Location Before End Iteration	Value	End Location	value
Pso1	(2,1)	208	(3,1)	124	(5,3)	238
Pso2	(12,11)	236	(5,3)	238	(5,3)	238
Pso3	(6,7)	232	(9,9)	223	(5,3)	238
Pso4	(8,9)	234	(9,9)	223	(5,3)	238
Pso5	(8,8)	88	(9,11)	149	(5,3)	238



Figure(3): Relationship between locations and values by Dev-PSO algorithm

The relationship of locations and values that selected by developed PSO is shown in Figure (3), . The some locations with its values located by developed PSO algorithm are shown in table (2).

Table(2) :Some values and locations selected by developed PSO

S	Value	Location in two dimension	Location in two dimension
1	236	1220	(21, 20)
2	187	1221	(21, 21)
3	135	1222	(21, 22)
4	90	1223	(21, 23)
5	154	1163	(20, 23)
6	84	1162	(20, 22)
7	189	1161	(20, 21)
8	39	1160	(20, 20)
9	236	1220	(21, 20)
10	155	1219	(21, 19)

There are three images that used as cover or host image to perform the developed PSO algorithm on them. Each selected cover or host image has two states, the first state is with location that pointed by green color and the second state is without location. All that are shown in Figure (4).

Figure(4): Three original images with and without location using developed PSO algorithm

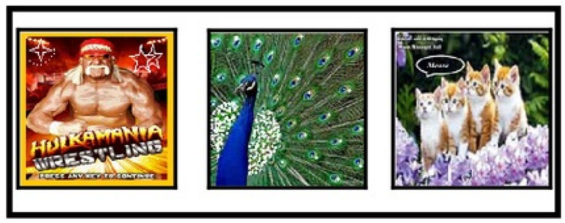
The relationship between number of iterations and required time for each iteration when using the developed PSO algorithm is shown in Table (3).

Table: (3) Iteration and Time for Dev- PSO.

Iteration No.	Time in sec.
1	3

VII. Quality Metrics Results

Figure (5) shows all stego images. The quality metric such as MSE and PSNR are computed for the original and cover images as shown at figure (4(a,c,e)). Values of images quality assessment are shown in table (4).



Figure(5): Final images after hiding process

Table (4): Values of images Quality Assessment

Image no.	MSE Value	PSNR Value
Image 1	0.00711	80.74
Image 2	0.00797	80.01
Image 3	0.00659	81.5

VIII. Conclusions

a developed swarm intelligence algorithm is proposed. The PSO algorithm is developed to determine an optimal solutions from search space of problem. After using the developed PSO algorithm on three images, notice these images does not affected by a prominent distortion or noising on it as shown in figure (5), the experimental results of the developed PSO algorithm and hiding process by using LSB technique are accepted and good since the quality of these images is good as shown in table (4) that describes the relationship between PSNR and MSE. Notice that when the PSNR is high, then the MSE is low. This indicates that the developed PSO algorithm has good performance and high efficient in hiding a secret message in the digital color images. The selecting accuracy of the best location when using the developed PSO algorithm is shown in table (2) and figure (4). Notice that there are no information missing, this result indicates to level of accuracy in selecting the best location. also the selected locations are almost serially, this give us pointer that the developed PSO algorithm is fast. If the bird has predetermined for starting point then all birds follows it.

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