Hiding a Secret Information in Image Using Gravitational Search Algorithm

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Abstract

Information is so important thing to us. Therefore, protecting the data by using information concealing techniques have become interest in the most applications. This paper proposed new algorithm is gravitational search algorithm in order to determine best locations in a carrier image (color image) that will be used to conceal secret information by effective and efficient method, this paper propose an effective and efficient method for determining best hiding locations in a carrier (colored image) by using gravitational search algorithm. The gravitational search algorithm is depended on gravity rules that concerns the fact that an object with mass attracts one another. The PSNR of the stego image1 and stego image2 are 72.55 and 71.21 respectively.

Keywords: Gravitational Search algorithm, Information hiding, Cover image, Stego Image, secret information, PSNR.

اخفاء المعلومات السرية في الصورة بأستخدام خوارزمية بحث الجاذبية

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الخلاصة

المعلومات هو شي مهم لنا. وبالتالي حماية المعلومات بأستخدام تقنيات اخفاء المعلومات اصبحت مهمة في عدد من المجالات التطبيقية. هذا البحث يقترح هذا البحث يقترح طريقة مؤثرة وفعالة لتحديد افضل مواقع اخفاء في الصورة الملونة الحاملة بأستخدام خوارزمية بحث الجاذبية. خوارزمية بحث الجاذبية تعتمد على قواعد الجاذبية التي تستند الى حقيقة ان كل جسم ذو كتلة تجذب جسم اخر ذو كتلة. النسبة العليا للأشارة الى الضوضاء للصورة الحاملة الاولى و الثانية هي 72.55 و 71.21 بالتعاقب.

الكلمات المفتاحية : خوارزمية الجاذبية ، اخفاء المعلومات ، صورة الغطاء ، الصورة المخفى بها، المعلومات السرية ، مقياس جودة الصورة

Introduction

In recent years and with quick growth of internet applications, almost everything has become digitally. The information that are transmit electronically is growing extremely [1]. Unauthorized user who may attempt to overhear this conversation can either tamper with this information to change its original meaning or it can try to listen to the message with intention to decode it and use it to his/her advantage. Both these attacks violated the confidentiality and integrity of the message passed [2]. Steganography (information hiding) is a system to protect secret data in the carrier media. The goal of the system is not only to ensure that the secret message sent in secret, but make the transmitter process is invisible, it is the art of the invisible transmitter process and provide denial in the policy of confidential communications [3]. The host media must include the most of its original content. The hidden media should be concealed with certain robustness so that the secret can resist certain attack [4].

Steganography Process

The term steganography is come from Greek and indicate to “covered writing”. A Steganography technique contains 3 parts: cover-image (which used to hides the secret data), the secret data and the stega-image (which is the carrier image with secret data concealed in it) [5]. Majority of the data and information that hide are image, therefore image steganography indicate to the process of setting confidential data in the image by the sender and is sent to the receiver, the receiver then extract the hidden information from the stego image by using stego key (key provided by sender) [6]. The major aim is that the confidential data will not be observed if unauthorized user attempts to intercept the cover media. The operation of extract confidential data from the carrier image is easy because it is mirrored of the concealment process, where the confidential data is detected at the finish. The figure (1) display the process of steganography system. The result of the steganographic system is the stego message. The carrier media should be as same data type as stego image, but the secret data may be in any data type. [7]

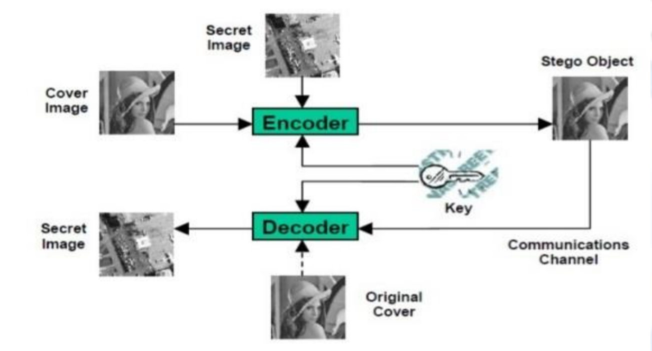

Figure 1: A general steganography system

Gravitational Search Algorithm (GSA)

GSA was introduced by Rashedi and is proposed to solve optimization problems and to enhance the efficiency in the reconnaissance and investment abilities of population based algorithm, depend on the rules of gravity. The population-based heuristic algorithm is based on the law of gravity and mass interactions. The gravity force causes a global movement where all objects move towards other objects with heavier masses. The slow movement of heavier masses guarantees the exploitation step of the algorithm and corresponds to good solutions [8]. which says that" every massive particle in the universe attracts other massive one with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them" [9]:

$F=G.(M_1.M_2/R_2)$ ……………………………...…………………………………(1)

in which M_1 and M_2 are two particles, R_2 is the distance between them, G is a gravitational constant and F is the magnitude of the gravitational force. The G is constant:

$G(t) = G(t_0)\ (t_0\ \beta / t),\ \beta < 1,$ …………………………….……….(2)

in which G(t) is the value of gravitational constant at time t, and $G(t_0)$ is the value of the gravitational constant at the time of the "creation of the universe" that is being considered. Newton's second law says that when a force f is applied to a mass, its acceleration A only depends on the force and its mass m:

$A = F/M$…………………………..……………………….…………….(3)

Based on above definitions, the (GSA), known as:

Let $X = [x_1, x_2, \ldots\ x_m]$ be an universe with m masses, such that x_i belong to $R_{n,}$ where i=1,2,…..m, X represent the positions. One can define, at a specific time t, the force acting on mass i from mass j in the d^{th} dimension as following:

$F_{ij}^{d} = G(t)\ (M_i(t)\ M_j(t)\ /R_{ij}+e)\ (x_{jd}(t) - x_{id}(t))$ ……………….(4)

Where $R_{ij}(t)$ is the Euclidean distance between masses i and j, and e is a small constant. In order to give a stochastic behavior to GSA, assume the total force that acts on agent i in a dimension d as a randomly weighted sum of the forces exerted from other agents:

$F^{d}_{i}(t) = \sum_{j=1, j\neq i}^{m} yj\ F^{d}_{ij}(t)$ ………………...…………………………………(5)

In which yj denotes a randomly generated number between 0 and 1. The acceleration of mass I at time t and dimension d is given by:

$a_i^{d}(t) = (F_{di}(t))\ /M_i(t)$ ……………………………………………..…...…...(6)

In which the mass Mi is calculated as follows:

$Mi(t) = (qi(t)\ /\sum_{j=1}^{m} qj\ (t)$ ………………………………………….……..…..(7)

With

$qi(t)=(fi(t) - w(t))/b(t) - w(t)$… ……………………..…………….……….…..(8)

the term w(t) and b(t) mean, respectively, the masses with worst and best fitness value, where the value of w(t) is worst (min) fitness for all agents at each iteration and b(t) is best(max) fitness for all agents at each iteration. The term $f_i(t)$ denotes the fitness value of mass i. Hence, equation (5) is rewritten as:

$F^{d}_{i}(t) = \sum_{j\in k, j\neq i} y_i F^{d}_{ij}(t)$ ……………………………………...……….……(9)

The equations (10) and (11) used for updating velocity and position respectively

$V^d_i (t+1) = y_j v^d_i(t) + a^d_i (t)$ ………………………………………………………….….…….(10)

$X^d_i (t+1) = x^d_i (t) + v^d_i (t+1)$……………………………………………….……….…...….(11)

Proposed Method

1. Applied GSA

The main idea is to use the GSA to determine the optimal locations in the carrier image, the carrier image is (128*128) pixel and it is represented as array of two dimension to the GSA algorithm, where the cover image is divided into 4 imaginary parts (part1, part2, part3, part4) as shown in figure (2), and each part with size (32*32) and the center of each part is the point (16,16) , then the fitness is calculated for every location of the image and calculated by using

function Z(s)=z(s)/z(sm) ………..……………(12)

where z(s) is fitness of the object (s), and z(sm) is total fitness of all objects, where the fitness of the object (s) = value (s) = (pixel value), then GS algorithm according to algorithm number (1) is applied parallel on the four sections and block diagram of applied GS algorithm to find the best locations is shown in figure (3)

Figure 2: Four imaginary sections of image

Algorithm 1: Applied GSA to find Optimal Locations of The Carrier Image

Input: Initialization of static parameters: iteration=300, G=0.0048, yi=0.5, carrier image =128*128 pixel.

Output: Determined locations that visited by (GSA).

Begin

Step1: Divided the carrier image into four imaginary section equally.

Step2: Calculate the fitness function for each object (x) in the search space by using Eq.(12).

Step3: Generate initial position (fac) of 4 agents at the center of each section, and the value of agent=pixel value

Step4: For each section do

(a) Calculate the value of mass (m) for each object (x), where mass(m)=fitness object(x),

(b) Calculate the value of F between every two objects according to Eq. (1).

(c) Evaluate the velocity and position for each agent in the section according to Eq. (10) and Eq.(11) where yi =0.5, vdi= value of the agent's fitness.

(d) Comparing current agent fitness value (fac) with local agents fitness value (ba).

(e) If (fac) > (ba) then change the location of (fac) with (upper or lower or right or left).

(f) If (fac) < (ba) then fac = max(ba).

(g) put max(ba) location in the list (L) to be the best location without repetition.

(h) Update velocity according to Eq.(10) and position according to Eq.(11).

(i) If number of iteration $\neq$300 then go step 4(c).

End

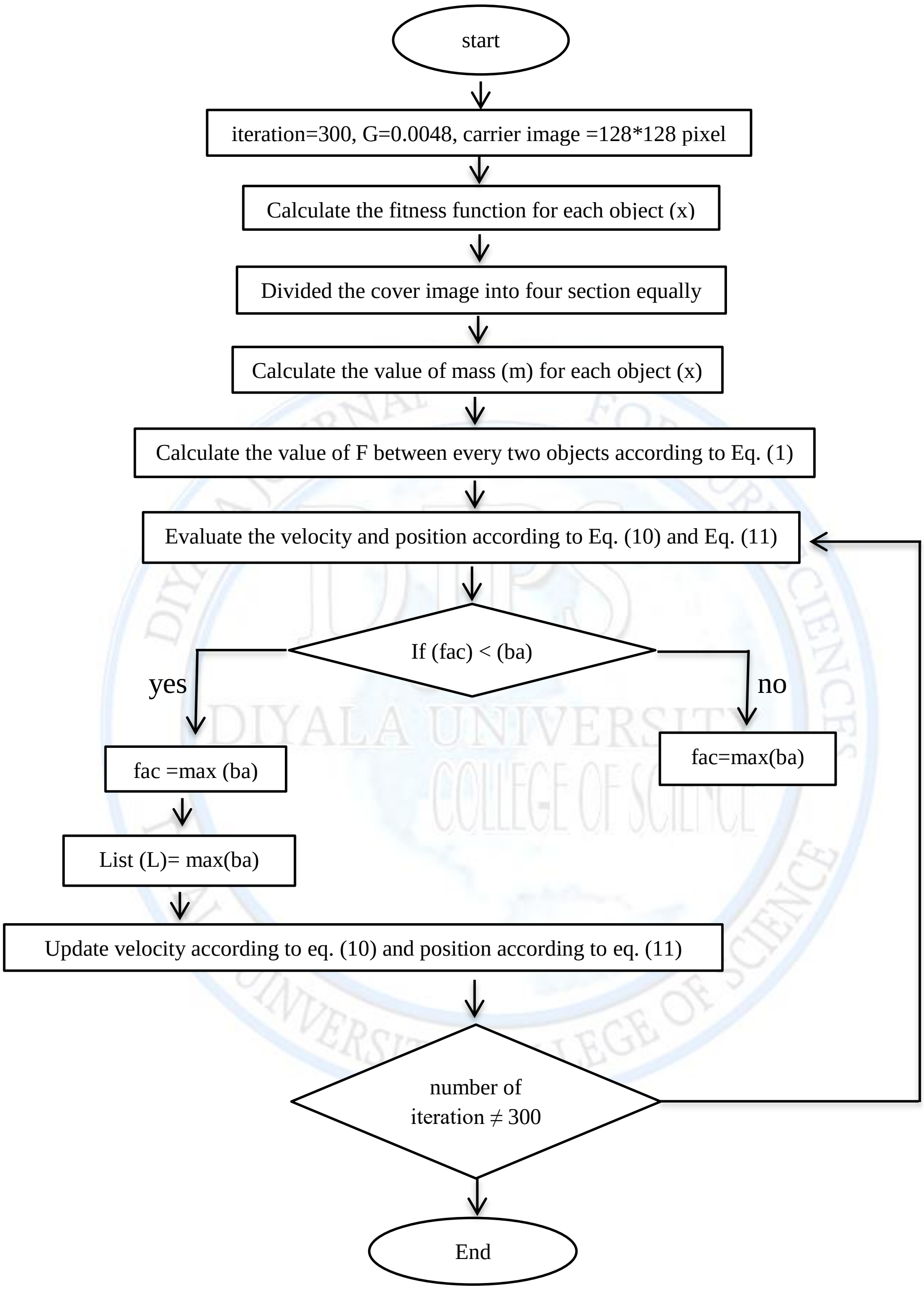

Figure 3: Block Diagram of Hiding Secret Information Using GSA

B. Hiding Process

The secret information convert into its binary values and equal to 3600 bit which represent confidential information, also the values of the 1200 best location of the cover image (128*128) pixel that are selected by GS algorithm are splitting into three basic values that represent the basic three colors (Red, Green, Blue) and then it convert to the binary values, the color of each location can hide three bit in the its least significant bit, there for each location will hide 3 bit form the secret information, the figure (4) shown the diagram of the hidden process

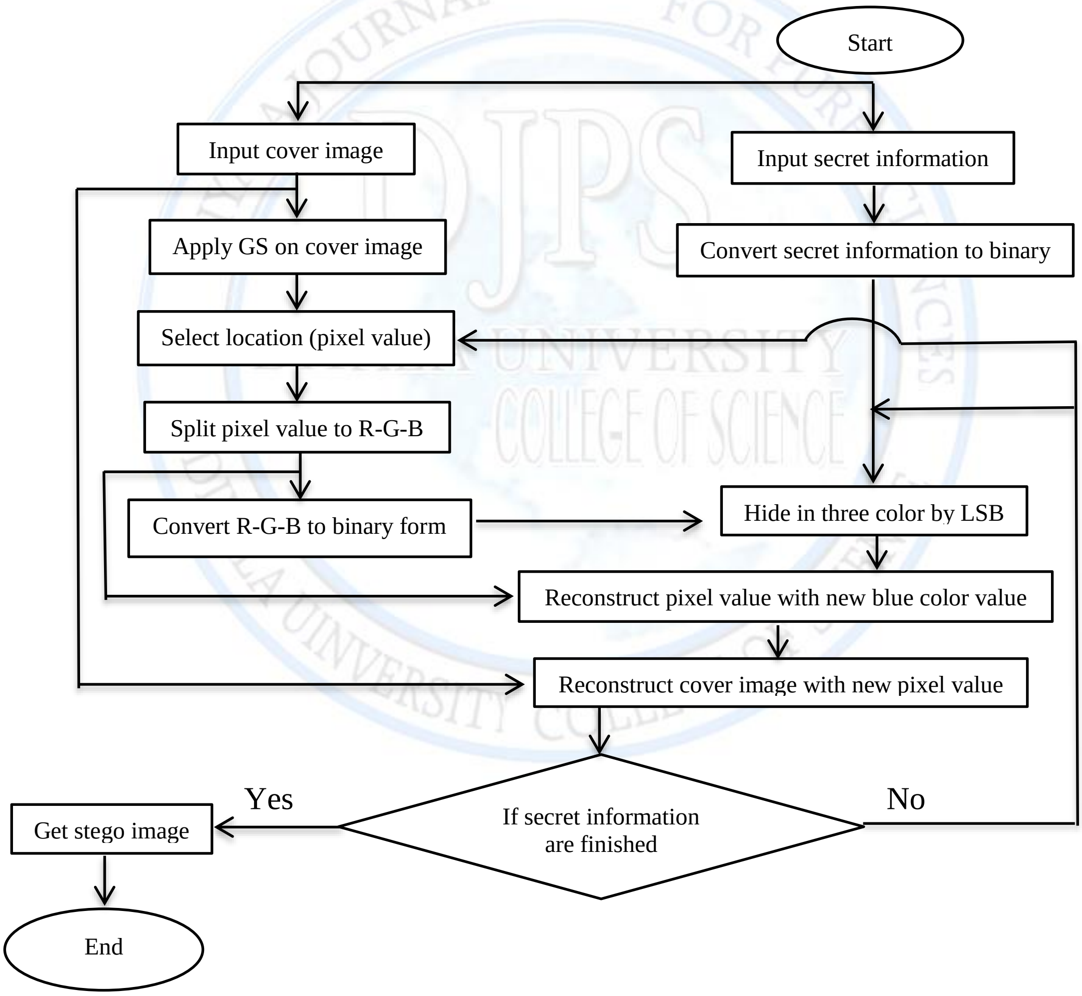

Figure 4: Block Diagram of Hiding Secret information Using GSA

Results

The performance and efficiency of GS algorithm that are applied to determine the optimal solution of the carrier for the first 4 locations that are selected in each section for each agent of the image (1) and image (2) is shown in table (1) and table (2).

Table 1: Location selected by GS with its values for image (1)

S	2-D Location	1-D Location	Values	GS No.	S	2-D Location	1-D Location	Values	GS No.
1	(22,114)	14373	255	1	9	(80,29)	3639	255	3
2	(28,113)	14252	235	1	10	(75,29)	3631	250	3
3	(27,97)	12219	180	1	11	(118,72)	9135	236	3
4	(97,71)	8987	169	1	12	(104,107)	16106	199	3
5	(108,39)	4934	255	2	13	(83,29)	3639	255	4
6	(19,19)	2305	157	2	14	(77,29)	3633	255	4
7	(17,19)	2303	157	2	15	(127,127)	16129	168	4
8	(101,127)	16103	157	2	16	(100,127)	16102	160	4

Table 2: Location selected by GS with its values for image (2)

S	2-D Location	1-D Location	Values	GS No.	S	2-D Location	1-D Location	Values	GS No.
1	(26,97)	12218	255	1	9	(18,114)	14369	255	3
2	(12,71)	8902	216	1	10	(95,113)	14319	245	3
3	(118,70)	8881	190	1	11	(22,106)	13357	137	3
4	(120,50)	6343	167	1	12	(106,51)	6456	126	3
5	(26,106)	13361	255	2	13	(126,127)	16128	255	4
6	(25,106)	13369	234	2	14	(124,127)	16126	245	4
7	(100,51)	6450	198	2	15	(103,127)	16105	198	4
8	(13,19)	2299	154	2	16	(102,127)	16104	186	4

Figure (5) show two cover images with and without the locations that are selected by GS algorithm. It is noted that the algorithm was applied to four sections of the image where the locations chosen by the algorithm were colored in green, figure (6) and figure (7) show the relationship between the locations and its values for stego image (1) and stego image (2) respectively and for the upper right section only, also the locations selected are random (non sequential) and have a large fitness which increases security factor and reduces the possibility of image confusion.

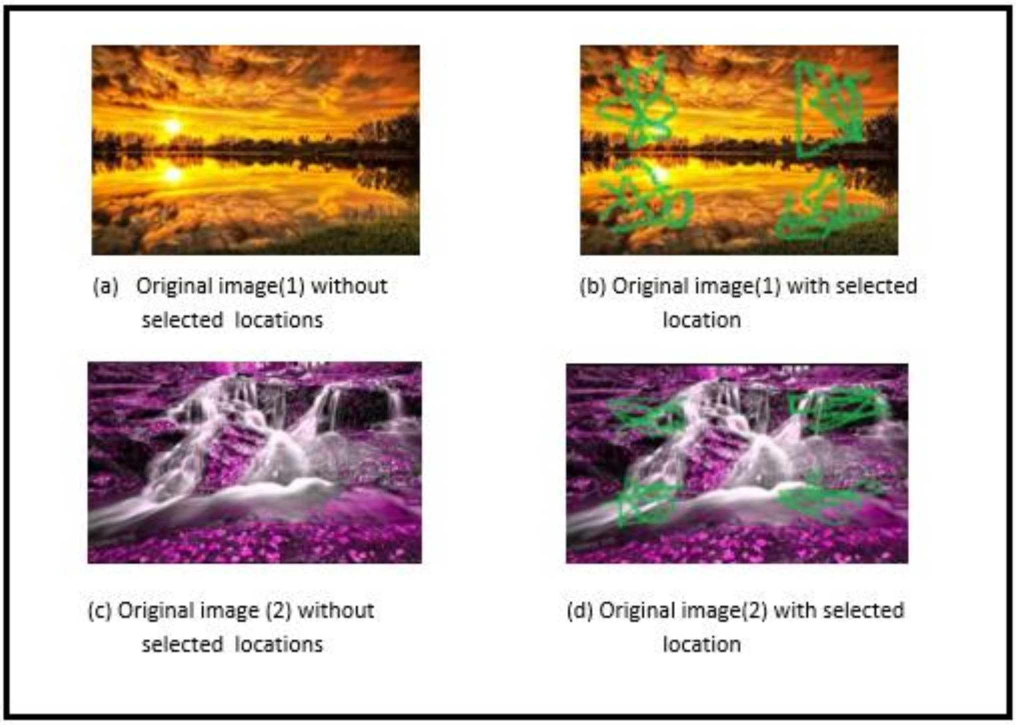

Figure 5: Cover Image with and without Selected Locations by GSA algorit

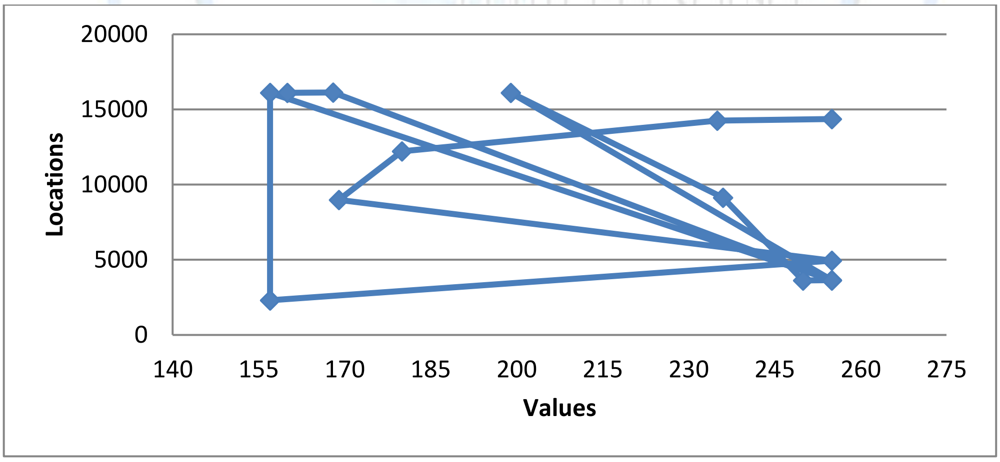

Figure 6: The Relationship Between the Locations and its Values for Stego Image (1) for the Upper Right Section.

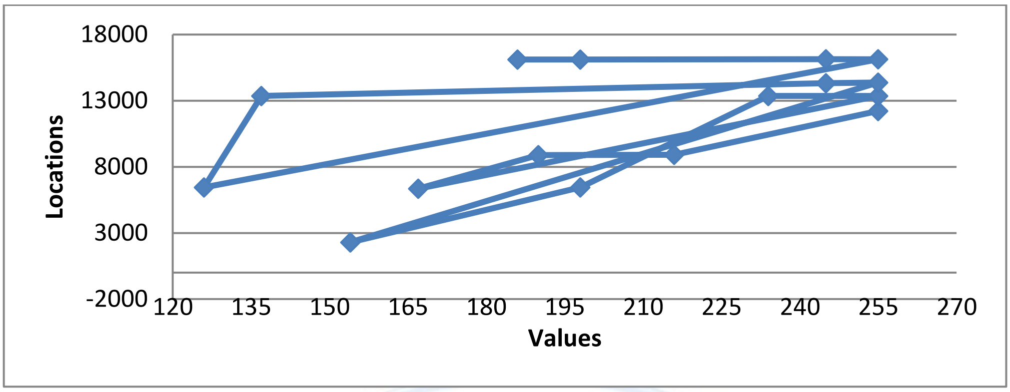

Figure 7: The relationship between the locations and its values for stego image (2) for the Upper Right Section.

Table (3) shows the times for the first ten iteration required for GS algorithm.

Table 3: Time and Iteration for GS algorithm.

No. of Iteration	Time (sec)	No. of Iteration	Time (sec)
1	2.5	6	1.8
2	2.3	7	1.9
3	1.9	8	2
4	2.2	9	2.4
5	2.1	10	1.8

The stego images are shown in figure (8). The MSE and PSNR are calculated between the original cover images at figure (5(a,c)) and the stego covers at figure (8). Quality metric values are shown in table (4).

Stego image (1)

Stego image (2)

Table 4: Quality Metrics Values

Image	MSE	PSNR
Image 1	0.0070	72.55
Image 2	0.0087	71.21

Conclusions

This work presents a successful GS algorithm, because of:

1. The time taken for the embedding process is 2.5 seconds which is very little time as shown in table (3).
2. Experimental results as observed in table (4) show high PSNR value and low MSE value for reconstructed images, that refers to good quality of reconstructed image.
3. Increase security, figure (6), figure (7) and figure (8) shown the selected locations are random (not sequential).
4. Provides speed because it works in an organized and efficient fashion.

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