

Hiding A Secret Watermark In Image Using Intelligent Water Drops Algorithm

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Abstract

Information hiding is one of the great significance in our lives today. Especially when it is sent from one place to another place (from sender to receiver) so it is necessary to find an excellent way to hide this secret information. In this paper we will use the Intelligent Water Drops Algorithm (IWDA) to find the best locations in the cover image (color image) that will be used to hide secret watermark image, this algorithm is used to find the best solutions in the search space by depending on their behavior to reach the goal quickly and efficiently, the (IWD) is nature-inspired swarm-based optimization algorithm, it is depend on the processes that occur within natural river system to find the best paths among many paths and can get-away from local optima more readily than evolutionary algorithms. The PSNR value for new objective (stego image) it has been measured, and it was very good, where the PSNR value for the image (1) and the image (2) were 82.74 and 81.71 respectively.

Keyword : IWD algorithm, Information hiding, Cover image, Stego Image, Secret watermark image, PSNR.

اخفاء العلامة المائية السرية في صورة باستخدام قطرة الماء الذكية

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الخلاصة

اصبح لأخفاء المعلومات اهمية كبيرة في حياتنا اليوم. و خاصة عندما يراد ارسال معلومات مهمة من جهة (المرسل) الى جهة اخرى (المستلم). في هذا البحث استخدمت خوارزمية جديدة و هي خوارزمية قطرة الماء الذكية في ايجاد افضل الاماكن في الصورة الملونة التي سوف تستخدم لاحقا في اخفاء البيانات لخرن المعلومات السرية فيها. هذه الخوارزمية تقوم بأيجاد المواقع المهمة بالاعتماد على تصرفها في الوصول الى الهدف بسرعة و كفاءة عاليين. ان خوارزمية قطرة الماء الذكية هي خوارزمية مستوحاة من مجاميع الاسراب الموجودة في الطبيعة وهي تعتمد على العملية التي تحدث في نظام النهر الطبيعي في ايجاد مسار للنهر من بين كل المسارات وبالتالي فان المسار الذي سيسلك سوف يعتبر هي المواقع المفضلة للخوارزمية للاخفاء. تم حساب قيمة ال (PSNR) للصورة التي تم فيها الاخفاء وكانت جيدا جدا وكانت قيمتها للصورة الاولى والثانية هي 82.74 و 81.71 بالتعاقب.

الكلمات المفتاحية: خوارزمية قطرة الماء الذكية ، اخفاء المعلومات ، صورة الغطاء ، الصورة المخفى بها ، العلامة المائية السرية ، مقياس جودة الصورة

Introduction

One of the causes that unauthorized persons can be successful is that most of the information they obtain from a system is in a form that they can read and comprehend. unauthorized persons may detect the information to others, modify it to corrupt an individual or organization, or use it to launch an attack. One solution to this problem is, through the use of steganography. Steganography is a technique of hiding information in digital media. In contrast to cryptography, it is not to keep others from knowing the hidden information but it is to keep others from thinking that the information even exists [1]. The major aim of steganography is to hide information in the other cover media so that other person will not notice the existence of the information [2]. Steganography and encryption are both used to ensure data confidentiality. However the major difference between them is that with encryption any person can see that both sides are communicate in secret. Steganography hides the existence of a secret message and in the best case no person can see that both parties are communicate in secret. This makes

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steganography proper for some tasks for which encryption aren't, such as copyright marking [3].

Steganographic process

Steganography is the art of hiding and transmitting data through obviously unhurt carriers in an effort to hide the existence of the data, the word steganography literally means wrapped or hiding writing as derived from Greek [4]. Image steganography system is include two algorithms, one for embedding and one for extraction. The embedding process hides a secret message within a cover media, and the result of embedding process is stego image. The major issue is that the secret message will not be unnoticed if unauthorized user tries to intercept the cover media (cover image). The extraction process is simply because it is the inverse of the embedding process, where the secret message is revealed at the end [5]. A general steganography system is shown in Fig (1). It is assumed that the transmitter wishes to send via steganographic transmission, a message to a receiver. The transmitter starts with a cover message, which is an input to the stego-system, in which the embedded message will be hidden. The hidden message is called the embedded message. A steganographic algorithm combines the cover message with the embedded message, which is something to be hidden in the cover. The algorithm may, or may not, use a steganographic key (stego key), which is additional secret data that may be needed in the hidden process. The same key is usually needed to extract the embedded message again. The output of the steganographic algorithm is the stego message. The cover message and stego message must be of the same data type, but the embedded message may be of another data type. The receiver reverses the embedding process to extract the embedded message [6],[7],[8].

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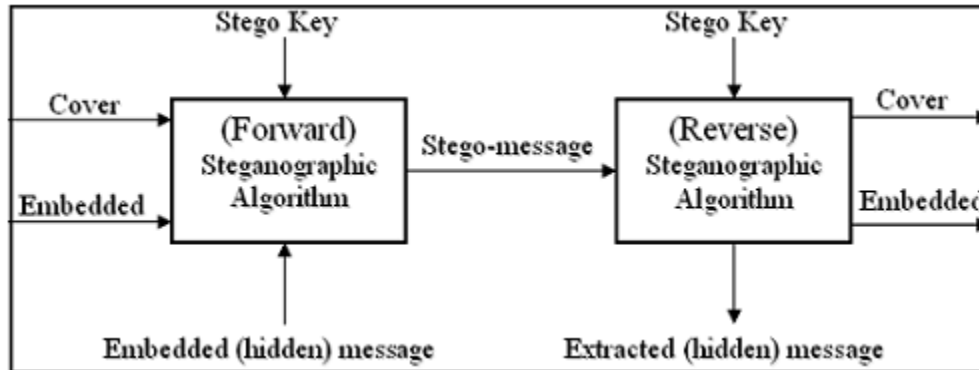


Figure (1) General Steganography System.

Intelligent water drops algorithm

The IWD algorithm is based on the dynamic of river systems, behaviors and responses that occur among the water drops in rivers. The natural water drops are used to develop IWD and the IWDs collaborate together to reach a better solution for a given problem. The IWD algorithm may be used for maximization or minimization problems. The solutions are incrementally constructed by the IWD algorithm. One iteration of the algorithm is finish when all IWDs have finished their solutions. After each iteration, the iteration-best solution T^{IB} is found and it is used to update the total-best solution T^{TB} . Then, the algorithm starts another iteration with new IWDs, the entire process is repeated. The algorithm stops when it reaches the maximum number of iterations $iter_{max}$ or the total-best solution T^{TB} reaches the expected quality. The IWD algorithm has two types of parameters. One type is those that remain constant during the lifetime of the algorithm and they are called 'static parameters'. The other type is those parameters of the algorithm, which are dynamic and they are reinitialized after each iteration of the algorithm. The IWD algorithm is fixed in the following phases [9]:

Input : Cover image

Output: Determined best locations in cover image

Begin

Step1: Initialization of static parameters. The quality of the total-best solution T^{TB} is at first set to the worse value: $q(T^{TB}) = -\infty$.

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The extreme number of iterations $iter_{max} = 500$.

The iteration count $iter_{count} = zero$.

The number of water drops NIWD = put a positive integer value.

The velocity updating, the parameters are $av = 1$, $bv = .01$ and $cv = 1$.

The soil updating, $as = 1$, $bs = .01$ and $cs = 1$.

The local soil updating parameter $pn =$ a small positive number less than one

The global soil updating parameter $P^{IWD} =$ from $[0, 1]$.

The first soil on each track = InitSoil such that the soil of the track between every two nodes i and j is set by $soil(i, j) = InitSoil$.

The first velocity of each IWD = InitVel.

InitSoil and InitVel = chosen by programmer.

Step2: Initialization of dynamic parameters. Every IWD has a visited location list Vc (IWD), which is initially empty: Vc (IWD) = { }. Each IWD’s velocity is put to InitVel. All IWDs are set to have zero amount of soil.

Step3: Firstly prevalence the IWDs randomly on the search space.

Step4: Update the visited location list of each IWD to include the locations just visited.

Step5: Repeat Steps 5.1 to 5.4 for those IWDs with partial solutions.

5.1 For the IWD staying in location i , select the next location j , which does not violate any constraints of the problem and is not in the visited location list $vc(IWD)$ of the IWD, using the following probability $P_i^{IWD}(j)$:

$$P_i^{IWD}(j) = f(soil(i,j)) / \sum f(soil(i,k)) \text{ where } k \text{ not belong to } vc(IWD) \dots\dots\dots(1)$$

$$f(soil(i,j)) = 1 / \epsilon_s + g (f(soil(i,j)))$$

$$g (f(soil(i,j))) = soil(i,j) \text{ if } \min (soil(i,j)) \geq 0 \text{ else}$$

$$g(f(soil(i,j))) = soil(i,j) - \min(soil(i,j))$$

Then, add the newly visited location j to the list $vc(IWD)$.

5.2 For each IWD moving from location i to location j , update its velocity $vel^{IWD}(t)$ by

$$vel^{IWD}(t+1) = vel^{IWD}(t) + (av / bv . soil^2(i,j)) \dots\dots\dots(2)$$

where the $vel^{IWD}(t+1)$ is the updated velocity of the IWD.

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5.3 For the IWD moving on the path from location i to j , compute the soil $\Delta\text{soil}(i, j)$ that the IWD loads from the path by

$$\Delta\text{soil}(i, j) = (as/bs + cs \cdot \text{time}^2(i, j, \text{vel}^{\text{iwd}}(t+1))) \dots\dots\dots(3)$$

Such that $\text{time}(i, j, \text{vel}^{\text{iwd}}(t+1)) = (\text{HUD}(j) / \text{vel}^{\text{iwd}}(t+1))$, the heuristic undesirability $\text{HUD}(j)$ is defined appropriately for the given problem.

5.4 Update the soil (i, j) of the path from location i to j traversed by that IWD and also update the soil that the IWD carries soil $^{\text{IWD}}$ by

$$\text{Soil}(i, j) = (1 - p_n) \cdot \text{Soil}(i, j) - P_n \cdot \Delta\text{soil}(i, j) \dots\dots\dots(4)$$

Step6: Find the iteration-best solution T^{IB} from all the solutions T^{IWD} found by the IWDs using $T^{\text{IB}} = \max(T^{\text{IWD}}) \dots\dots\dots(5)$

Step7: Update the soils on the paths that form the current iteration-best solution T^{IB} by $\text{Soil}(i, j) = (1 + P_{\text{IWD}}) \cdot \text{Soil}(i, j) \dots\dots\dots(6)$

Step8: Update the total best solution T^{TB} by the current iteration-best solution T^{IB} using $T^{\text{TB}} = T^{\text{TB}}$ if $q(T^{\text{TB}}) \geq q(T^{\text{IB}})$, otherwise $T^{\text{TB}} = T^{\text{IB}} \dots\dots\dots(7)$

Step9: Increment the iteration number by $\text{Iter}_{\text{count}} = \text{Iter}_{\text{count}} + 1$.
Then, go to Step 2 if $\text{Iter}_{\text{count}} < \text{Iter}_{\text{max}}$

Step10: The algorithm stops here with the total-best solution T^{TB} .

End.

Proposed method

The major aim of the proposed method is to provide secure connection between sender and receiver by using two techniques that the first is Intelligent Drop Water algorithm (meta heuristic algorithm) that used to find the best location in the search space (carrier image) to hide the secret watermark image, second technique is steganography that used least significant bit algorithm to hide the secret watermark image in the last bit for each color (Red (R), Green (G), Blue (B)) of the cover image pixel.

The proposed system is consist from the following stages

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A. Applied IWD algorithm

In this stage the cover image (color image) of the size 128*128 pixel is presented to the IWD algorithm as array of two dimension (M.N), where M is image width and N is image height, to applied the IWD algorithm we must do the following steps,

Input: Initialization of static parameters: $q(T^{TB}) = -\infty$, $iter_{max} = 500$. $iter_{count} = zero$.

$NIWD = 1$, $av = 1$, $bv = 0.01$ and $cv = 1.00$. $as = 1.00$, $bs = 0.01$, $cs = 1.0$, $pn = 0.0101$, $P^{IWD} = 0.99$, $InitSoil=0.0$, $InitVel=0.0$.

Output: Determined the locations that visited by (IWD)

Step1: Identify the first location (fl) of the IWD, where fl=center of the search space, and each IWD in the search space is a solution, fl has directed path to the another location and in all direction, as shown in figure (2), where the IWD at location (M_2, N_2) have direct path to the following locations $\{(M_1, N_1), (M_1, N_2), (M_1, N_3), (M_2, N_1), (M_2, N_3), (M_3, N_1), (M_3, N_2), (M_3, N_3)\}$,

Step2: The IWD must visit new locations in the search space and put new location in the V_c (IWD) list that is initially empty

Step3: Each IWD have two main factor to move from source to destination that are velocity and soil, the initial value of soil is selected and equal to zero because the drop is do not moving, and initial value of velocity is represent the value of that location that stand it.

Step4: Calculate the value of the soil and velocity for each locations that are surrounding to the location that have a IWD according to the following questions

$$\Delta soil(i, j) = (as / bs + cs.time^2(i,j,vel^{iwd}(t+1))) \dots\dots\dots(8)$$

Such that $time(i,j,vel^{iwd}(t+1)) = (HUD(j) / vel^{iwd}(t+1))$, the heuristic unfavorable

$HUD(j)$ is defined appropriately for the given problem

$$Soil(i,j) = (1-pn). Soil(i,j) - Pn . \Delta soil(i, j) \dots\dots\dots(9)$$

$$vel^{IWD}(t+1) = vel^{IWD}(t) + (av /bv .soil^2(i,j)) \dots\dots\dots(10)$$

where the $vel^{IWD}(t+1)$ is the updated velocity of the IWD

Step5: For first iteration, the value of velocity of the current location (VC) of the drop with all velocities of its surrounding locations (VS), if $(VS) > (VC)$ then (VC) go to max (VS)

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else go back step (2) to change the location of the drop by one step to up or down or left or right.

Step6: After first iteration, compare the values of velocity (VC) and soil (SC) of the current location with the values of velocity (VS) and soil (SS) of its surrounded locations, if $(VC) \geq (VS)$ then compare (SC) and (SS) then (VS) go to min (SS) location, $min(SS)=(VS)$.

Step7: Every location visited by drop is put in the V_c list, to be best solution.

Step8: The iterations is continue until the max iteration ($max_{iter}=500$).

The block diagram of applied IWD algorithm to find the best locations is shown in figure (3).

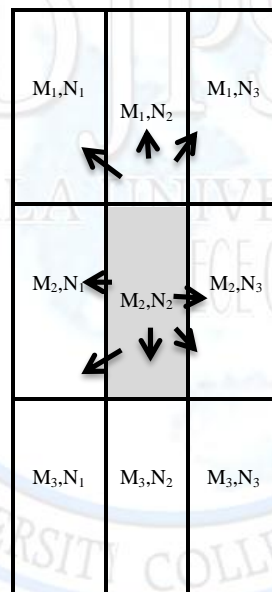


Figure (2): The direction of the each location.

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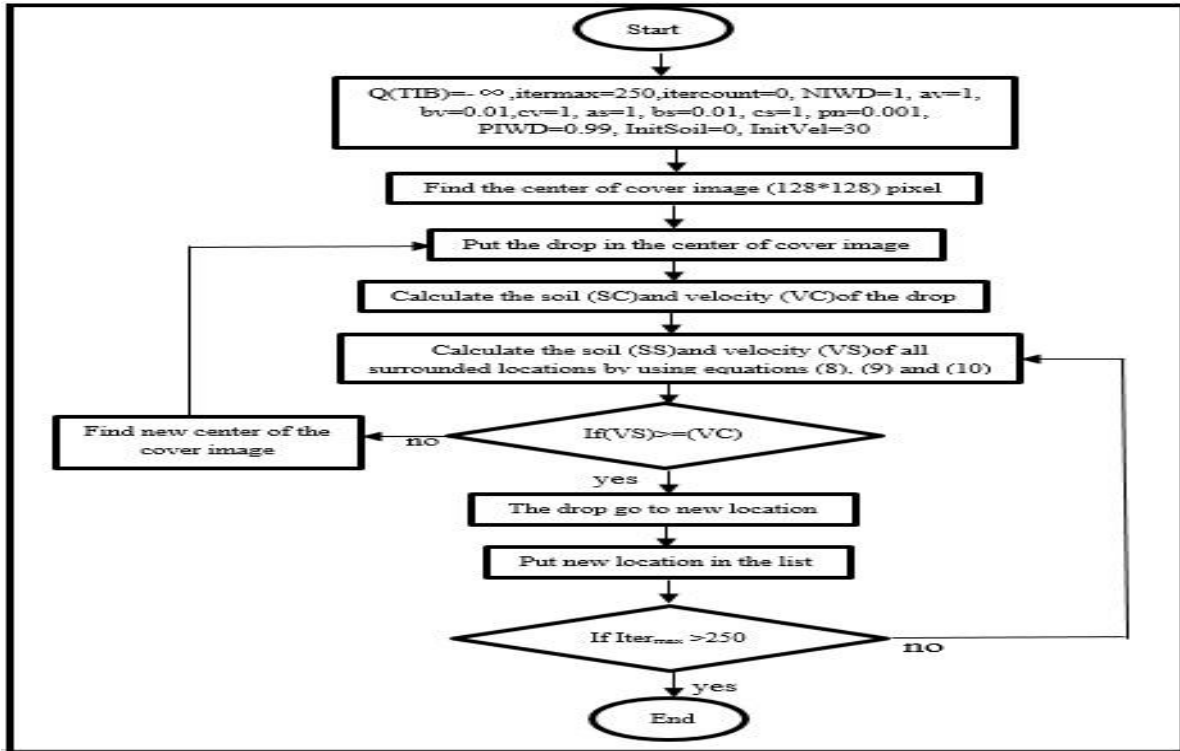


Figure (3): The block diagram of applied IWD algorithm.

B. Hidden Process

In this stage, it will be transferred the secret watermark image into its binary values and equal to 1500 bit, also the values of the 500 best location that are selected by IWD algorithm are splitting into three basic values that represent the basic three colors (Red, Green, Blue) and then it convert to the binary values, each color of one location can hide one bit in the its least significant bit, therefore each location will hide three bit form the secret watermark, figure (4) shown the diagram of the hidden process.

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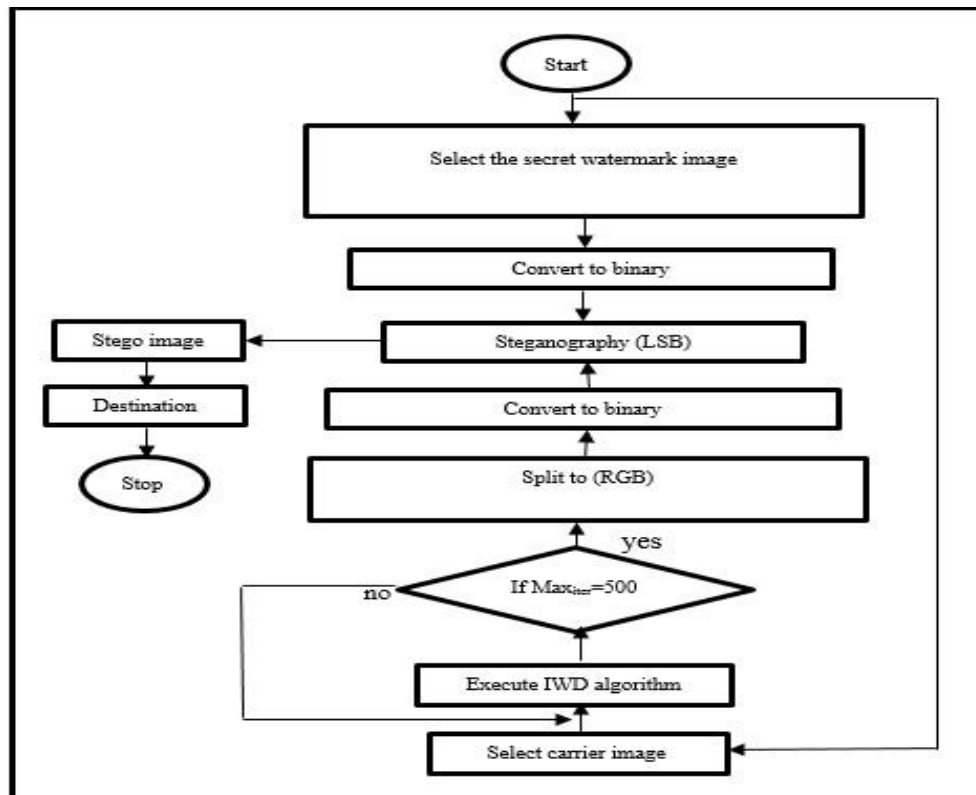


Figure (4): The diagram of the hidden process

Results

The performance and efficiency of IWD algorithm that are used to determine the best solution in search space is shown by results, figure (5) show the cover image and stego image, and that sites that have been selected by IWD algorithm are coded in red color, when looking at the stego image notice that the locations that have been selected are similar to a river bed. The table (1), (2) show some of the locations and its values that are selected by IWD algorithm for image (1), (2) respectively, where (S) represent the number of iterations, (locations) represent the locations of search space that are selected by IWD algorithm and (values) represent the value of color pixel for the locations that are selected by IWD algorithm, and the figure (6), (7) show the relationship between the locations and its values respectively.

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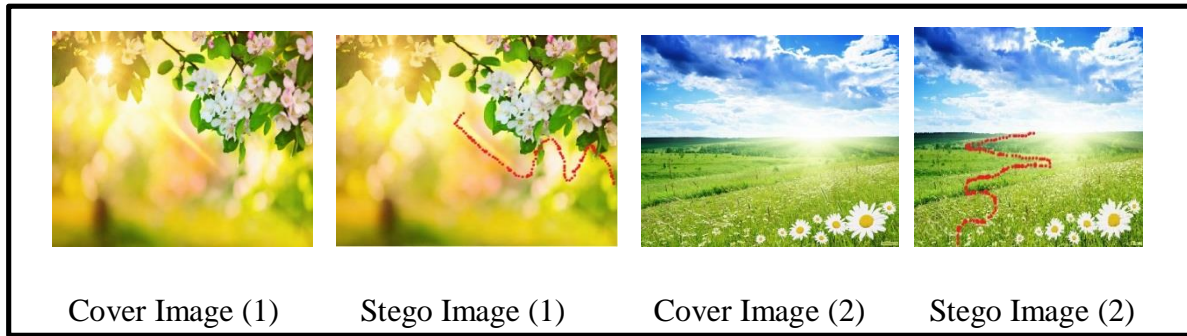


Figure (5): The cover image and Stego image.

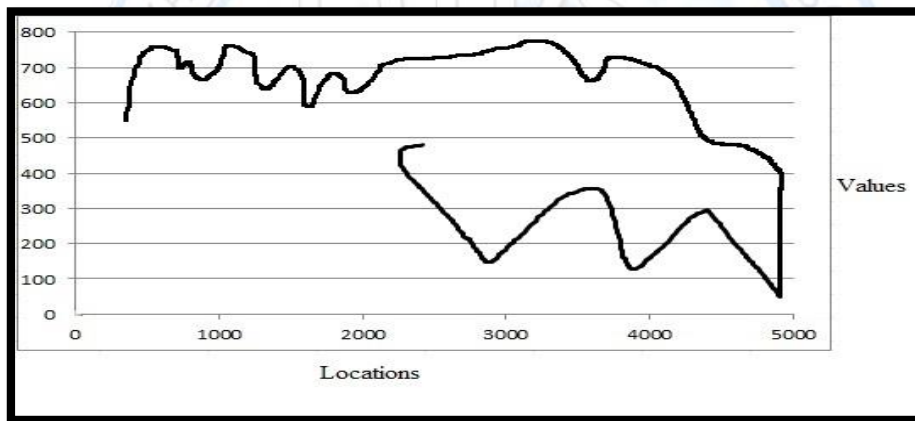


Figure (6): The relationship between the locations and its values for stego image (1).

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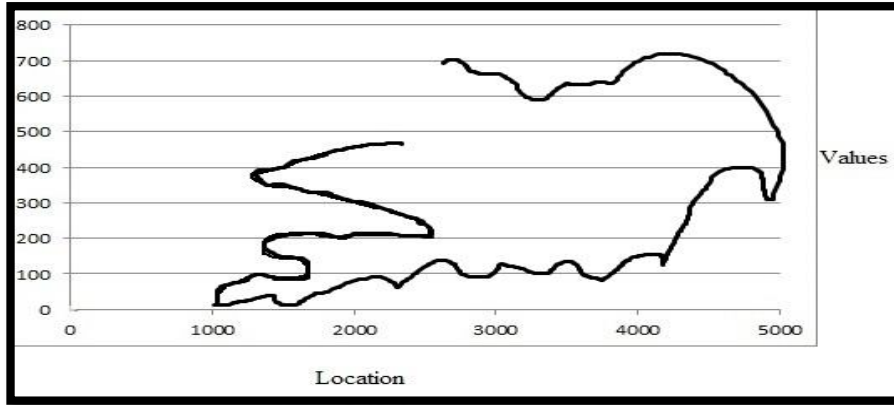


Figure (7): The relationship between the locations and its values for stego image (2).

Table (1): Some locations and its values for stego image (1).

S	Locations	Values	S	Locations	Values	S	Locations	Values	S	Locations	Values
1	2380	481	16	2801	450	30	3001	220	44	3077	269
2	2389	478	17	2812	449	31	3010	239	45	3079	272
3	2400	477	18	2825	446	32	3012	241	46	3081	274
4	2430	460	19	2829	445	33	3021	245	47	3082	275
5	2457	457	20	2833	444	34	3022	247	48	3091	276
6	2468	455	21	2839	442	35	3027	255	49	3093	278
7	2489	456	22	2844	440	36	3033	256	50	3096	279
8	2500	459	23	2848	436	37	3036	258	51	3100	283
9	2508	461	24	2853	431	38	3040	259	52	3110	285
11	2523	463	25	2859	428	39	3042	261	53	3120	287
12	2581	464	26	2899	423	40	3045	263	54	3122	289
13	2599	466	27	2913	421	41	3047	264	55	3126	290
14	2600	467	28	2917	417	42	3053	266	56	3130	292
15	2607	469	29	2929	419	43	3060	267	57	3132	295

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Table (2) Some locations and its values for stego image (2)

S	Locations	Values	S	Locations	Values	S	Locations	Values	S	Locations	Values
1	2550	497	16	2411	469	30	2350	445	44	2116	319
2	2547	495	17	2407	466	31	2344	443	45	2110	318
3	2546	494	18	2405	465	32	2341	441	46	2105	316
4	2538	491	19	2401	475	33	2336	437	47	2104	313
5	2535	489	20	2399	464	34	2333	435	48	2102	312
6	2532	488	21	2387	473	35	2331	343	49	2100	310
7	2529	480	22	2383	472	36	2330	342	50	2091	314
8	2526	486	23	2381	470	37	2325	349	51	2093	307
9	2523	478	24	2380	460	38	2323	346	52	2077	306
11	2521	475	25	2378	457	39	2320	432	53	2075	303
12	2517	474	26	2376	456	40	2319	430	54	2072	305
13	2513	471	27	2372	453	41	2317	325	55	2758	309
14	2510	470	28	2370	450	42	2312	323	56	2750	302
15	2501	479	29	2367	448	43	2309	321	57	2746	301

The Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR) are the two error metrics used as benchmark for evaluating performance of hiding, The MSE appears the cumulative squared error between the reconstructed image and the cover image, whereas PSNR represents a measure of the peak error. PSNR is identified as $10 \cdot \log_{10}$ of the ratio of the peak signal energy to the MSE observed between the processed image signal and the cover image signal. If the original image is O of size $Y \times Y$ and the reconstructed image is R of size $A \times A$, then each original image O and reconstructed image R will have pixel value (a, b) from 0 to Y-1 and 0 to A-1 respectively. The PSNR is then calculated as follows:

$$PSNR = 10 \cdot \log_{10}(MAX^2/MSE) \dots\dots\dots(11)$$

Where $MSE = 1/YA \sum_{a=0}^{Y-1} \sum_{b=0}^{A-1} (O(a, b) - R(a, b))^2$,

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Note that MAX is the grater possible pixel value of the images. If the reconstructed image has a higher PSNR value, then the reconstructed image has more quality image. Figure (8) show the original image and reconstructed image and table (3) shows the PSNR and MSE value for two reconstructed images. The PSNR is calculated using the equation of PSNR in Eq. (11). Based on values of PSNR from table (3), the PSNR values show that the reconstructed images have quality images without compromising of the original image. The image (1) have better PSNR value equal to 82.74 that refers to the fault ratio between carrier and stego image is small and equal to 0.0015, the image (2) also have best PSNR value equal to 81.71 and fault ratio equal to 0.0019 this results refers to the process of hidden by IWD algorithm is optimal.

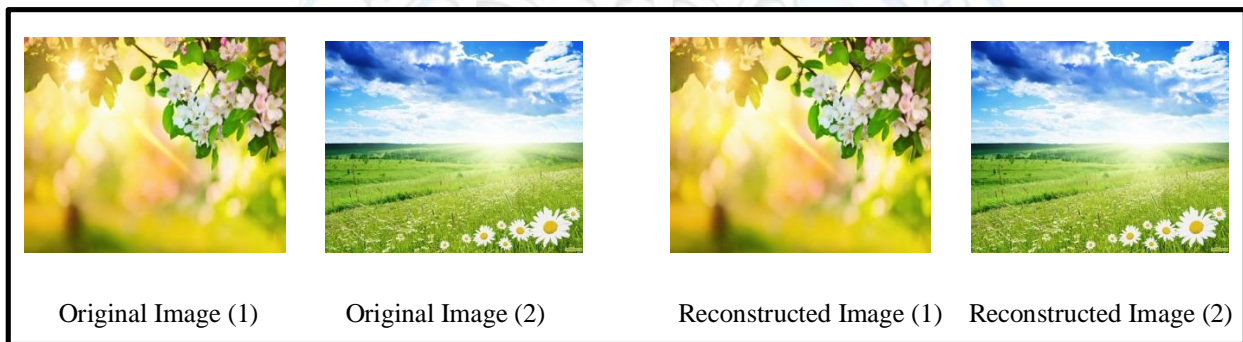


Fig (8): The Original and Reconstructed image.

Table (3): Values of PSNR and MSE.

Image	MSE	PSNR
Image 1	0.0015	82.74
Image 2	0.0019	81.71

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Conclusions

In this paper a new swarm intelligence algorithm is proposed. The IWD algorithm is applied to determine the best solution in the search space. Found that the reconstructed image does not have a prominent distortion on it as observed in figure (8), also the experimental results as observed in table (3) show high PSNR and low MSE for reconstructed images, that refers to good quality of reconstructed image, and the table (1),(2) show the accuracy in chosen the near best location without lose any of its, this indicates that algorithm is very fast because it works in an organized fashion and non- random. Hence this proposed algorithm (IWD) is very efficient to hide the information within the image.

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