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Enhancing the Capacity of LSB Method by Introducing LSB2Z Method

Ziad Alqadi[1]; Bilal Zahran[2]; Qazem Jaber[3]; Belal Ayyoub[4]; Jamil Al-Azzeh[5]

[1]Computer Engineering Department, Al Balqa'a Applied University, Amman, 11134, Jordan
E-mail: Natalia_maw@yahoo.com
[2]Computer Engineering Department, Al Balqa'a Applied University, Amman, 11134, Jordan
E-mail: zahranb@yahoo.com
[3]Department of Mechatronics Engineering, Al Balqa'a Applied University, Amman, 11134, Jordan
E-mail: qazemjaber@gmail.com
[4]Computer Engineering Department, Al Balqa'a Applied University, Amman, 11134, Jordan
E-mail: belal_ayyoub@hotmail.com
[5]Computer Engineering Department, Al Balqa'a Applied University, Amman, 11134, Jordan
E-mail: azzehjamil@gmail.com

Abstract: The purpose of steganography is to conceal the existence of the secret message in the holding image, thus making a message unreadable by a third party. Steganography is an important process due to many factors such as the confidentiality, personality of the message to be sent from the sender to receiver through unsecure communication environment. In this paper we will introduce LSB2 method of data hiding in order to double the capacity of the holding image, by doubling the maximum message size which can be covered by the image. The proposed methodology of applying LSB2 will be implemented and tested in order to prove the efficiency of this method comparing with LSM method.
Keywords: Steganography, LSB, LSB2, hiding time, extracting time, PSNR.

1- Introduction

True color image is a 3D matrix, the first dimension represents the red color, the second one represents the green color, while the third one represents the blue color [1-61]. Digital color image is one of the most popular data type used in the internet as a result of data communication between the sender and receiver over the internet . Color images are widely used by different users, and several applications need certain and consistent 'security in data communication and security in storing' [5], [6], such as medical imaging systems, pay-TV, confidential video conferences, and military image communications, so the need for data steganography must have a priority with highest level. Steganography is the art of hiding data into another data and it is very useful and applicable process for the following reasons [7], [8], [9, [10]:

- Personal data are very private and confidential.
- Data are very sensitive
- Confidential data and trade secrets
- Misuse of data is not acceptable.
- Data does not bear unintentional damage, or human error and accidental deletion.
- Data should not be exposed monetary and blackmail purposes
- Data does not deal with hiding traces of crime

Any data hiding technique shall express certain features such as:

- Capacity, which refers to the amount of data that can be hidden in cover medium [10], least significant bit (LSB) of data hiding, allows hiding a message with size equal the image covering size divided by 8. [10]
- Security, the data hiding method should provide security such that only the intended user can gain access to it. In other words, it refers to the inability of un-authorized user to detect hidden information. This is very crucial to protect the confidentiality and sensitivity of information being sent [3], [4].
- Robustness, which refers to the amount of data that can be hidden without showing any negative effects and destroying hidden information [1]. In other words making it difficult to distinguish them with the naked eye, here the mean square error(MSE) between the covering image and the holding one must be closed to zero [15], [16], [17], or here the used method of data hiding must give a big value of peak signal to noise ratio (PSNR) [18], [19].
- Perceptibility, the data hiding method should hide data in such a manner that the original covering data and the hidden data are perceptually indistinguishable.[5], [15].
- Efficiency, [11], [12], the used method of data hiding must hide and extract the secret message with minimum time or the method must provide a maximum throughput [13], [14].

2- LSB method of data hiding

LSB method of data steganography is a simple method, and it is popular and has being used in many applications [6], [7]. LSB method reserves 8 bytes from the holding image to hide one character from the secret message [9], [10], so the maximum message size to be covered must not exceed the image size divided by 8[6]. Figure (1) shows how to reserve bytes in the color image to be used for hiding the message character bits:

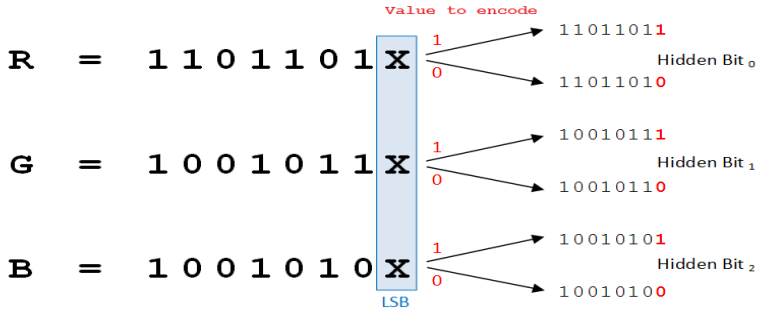

Figure (1): Reserving color bytes to hold a message character.

Table (1) shows how to use LSB method to hide the message "Ziad" in bytes of a covering color image:

Message= Ziad = **90 105 97 100**

Binary=**01011010 01101001 01100001 01100100**

Table (1): Hiding a message using LSB method

Red pixel	Decimal	Covering binary	Holding binary	Decimal	Red pixel	Decimal	Covering binary	Holding binary	Decimal
1	249	11111001	11111000	248	17	249	11111001	11111000	248
2	249	11111001	11111001	249	18	249	11111001	11111001	249
3	249	11111001	11111000	248	19	249	11111001	11111001	249
4	249	11111001	11111001	249	20	249	11111001	11111000	248
5	249	11111001	11111001	249	21	249	11111001	11111000	248
6	249	11111001	11111000	248	22	249	11111001	11111000	248
7	249	11111001	11111001	249	23	249	11111001	11111000	248
8	249	11111001	11111000	248	24	249	11111001	11111001	249
9	249	11111001	11111000	248	25	249	11111001	11111000	248
10	249	11111001	11111001	249	26	249	11111001	11111001	249
11	249	11111001	11111001	249	27	249	11111001	11111001	249
12	249	11111001	11111000	248	28	249	11111001	11111000	248
13	249	11111001	11111001	249	29	249	11111001	11111000	248
14	249	11111001	11111000	248	30	249	11111001	11111001	249
15	249	11111001	11111000	248	31	249	11111001	11111000	248
16	249	11111001	11111001	249	32	249	11111001	11111000	248

LSB method adds a minor changes to the holding image, so the third party will not notice any changes between the covering image and the holding image, thus LSB will optimize MSE and PSNR, table (2) shows the minimum changes (if they exist) in the holding bytes.

Table (2): Changes in the covering byte using LSB method

LSB of the covering byte	Character bit	Remarks
0	0	No changes in the covering byte
	1	Add 1 to the covering byte
1	0	Subtract one from the covering byte
	1	No changes in the covering byte

3- LSB2Z description and implementation

The proposed LSB2Z method of data hiding reserves 4 bytes from the covering image to be used to hide a message character, thus this method will double the size of the message to be hidden in a covering color image as shown in figure (2):

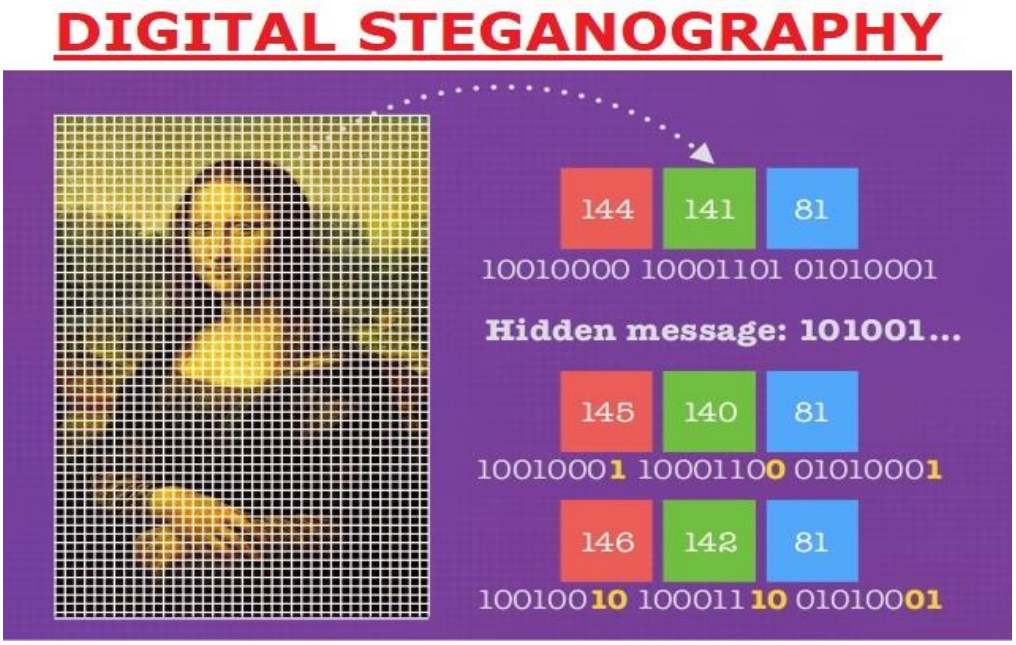

Figure (2): Steganography using LSB and LSB2Z

Tables (3) and (4) show how to hide and extract a character using LSB2Z method:

Data to be hidden (a1) =191= **10111111** binary

n=2

Table (3): Hiding using LSB2Z method

Byte value(b)	Binary	Holding byte	Binary
218	11011010	s(1)=uint8(bitor(bitand(b(1),bitcmp(2^n-1,8)),bitshift(a1,-6))); =218	11011010

200	11001000	a=bitand(a1,48); a=bitshift(a,2);
		s(2)=uint8(bitor(bitand(b(2),bitcmp(2^n-1,8)),bitshift(a,-6)));
		=203
			11001011

120	01111000	a=bitand(a1,12);a=bitshift(a,4);
		s(3)=uint8(bitor(bitand(b(3),bitcmp(2^n-1,8)),bitshift(a,-6)));
		=123
			01010011

190	10111110	a=bitand(a1,3);a=bitshift(a,6);
		s(4)=uint8(bitor(bitand(b(4),bitcmp(2^n-1,8)),bitshift(a,-6)));
		=191
			10111111

Table (4): Extracting character using LSB2Z method

Byte value(b)	Byte weight
217	d1=bitand(s(1),3); d1=bitshift(d1,6) =128
203	d2=bitand(s(2),3);d2=bitshift(d2,4) =48
123	d3=bitand(s(3),3);d3=bitshift(d3,2) =12
191	d4=bitand(s(4),3) =3
Hidden byte	128+48+12+3=191

Here we will describe the proposed method of hiding and extracting a character in/form a color image.

Hiding process:

To hide a character into a color image apply the following steps:

1) Get a character, get the decimal and binary values of the character (let us say: a1=191=**10111111**.
2) Reserve four bytes from the covering image (let us say b= [218 200 120 190]).
3) Find the complement of 3(11 in binary):cmp3=252.
4) Insert the first 2 bits in the first covering byte: to do this apply the following steps:
    A. Apply ANDING of the first byte with cmp3:

       C1=bitand (b (1), cmp3) =216.

    B. Shift right a1 6 times: C2=bitshift (a1,-6) =2.

    C. Get the first holding byte by ORING C1 and C2: S (1) =bitor (C1, C2) =218.
5) Insert the second 2 bits in the second covering byte: to do this apply the following steps:
    A. Apply ANDING a1 with 48: a=bitand (a1, 48) =48.

    B. Shift left a 2 times: a=bitshift (a, 2) =192.

C. Apply ANDING of the second byte with cmp3:

C1=bitand (b (2), cmp3) =200.

D. Shift right a 6 times: C2=bitshift (a,-6) =3.

E. Get the second holding byte by ORING C1 and C2: S (2) =bitor (C1, C2) =203.

6) Insert the third 2 bits in the third covering byte: to do this apply the following steps:

A. Apply ANDING a1 with 12: a=bitand (a1, 12) =12.

B. Shift left a 4 times: a=bitshift (a, 4) =192.

C. Apply ANDING of the second byte with cmp3:

C1=bitand (b (3), cmp3) =120.

D. Shift right a 6 times: C2=bitshift (a,-6) =3.

E. Get the second holding byte by ORING C1 and C2: S (3) =bitor (C1, C2) =123.

7) Insert the fourth 2 bits in the fourth covering byte: to do this apply the following steps:

A. Apply ANDING a1 with 3: a=bitand (a1, 3) =3.

B. Shift left a 6 times: a=bitshift (a, 4) =192.

C. Apply ANDING of the second byte with cmp3:

C1=bitand (b (4), cmp3) =188.

D. Shift right a 6 times: C2=bitshift (a,-6) =3.

E. Get the second holding byte by ORING C1 and C2: S (3) =bitor (C1, C2) =191.

Extracting process

This process can be implemented applying the following steps:

1) Get the four holding bytes S= [218 203 123 191].

2) Get the character first weight by applying the following steps:

A. ANDING the first holding byte with 3:d1= bitand(s (1), 3) =2.

B. Shift left d1 6 times: d1=bitshift (d1, 6) =128.

3) Get the character second weight by applying the following steps:

A. ANDING the second holding byte with 3:d2= bitand(s (2), 3) =3.

B. Shift left d1 6 times: d2=bitshift (d1, 4) =48.

4) Get the character third weight by applying the following steps:

A. ANDING the third holding byte with 3:d3= bitand(s (3), 3) =3.

B. Shift left d1 2 times: d3=bitshift (d1, 2) =12.

5) Get the character fourth weight by ANDING the fourth holding byte with 3: d4=bitand(s (4), 3) =3.

6) Find the character decimal value by summing the weights d1+d2+d3+d4=191.

This method also added a minor changes (if any) by adding a maximum of 3 or a subtracting -3 from the covering byte as shown in table (5):

Table (5): Changes in the covering byte

LSB2 of the covering image pixel	2 bits from the character to be hidden	Remarks
00	00	No change
	01	Add 1 to pixel
	10	Add 2 to pixel
	11	Add 3 to pixel
01	00	Subtract 1 from pixel
	01	No change
	10	Add 1 to pixel
	11	Add 2 to pixel
10	00	Subtract 2 from pixel
	01	Subtract 1 from pixel
	10	No change
	11	Add 1 to pixel
11	00	Subtract 3 from pixel
	01	Subtract 2 from pixel
	10	Subtract 1 from pixel
	11	No change

4- Implementation and experimental results

LSB and the proposed LSB2Z methods were implemented using matlab, several deferent color images in sizes and types were used as a covering and holding images, different messages in size were used to be hidden in the selected images.

Figures (3), (4) and (5) show the original covering image, the holding image using LSB method, and the holding image using LSB2Z method, the inserted message length was equal 100 characters. Looking to the holding image by eyes, it comes to us that these holding images are identical to the covering image.

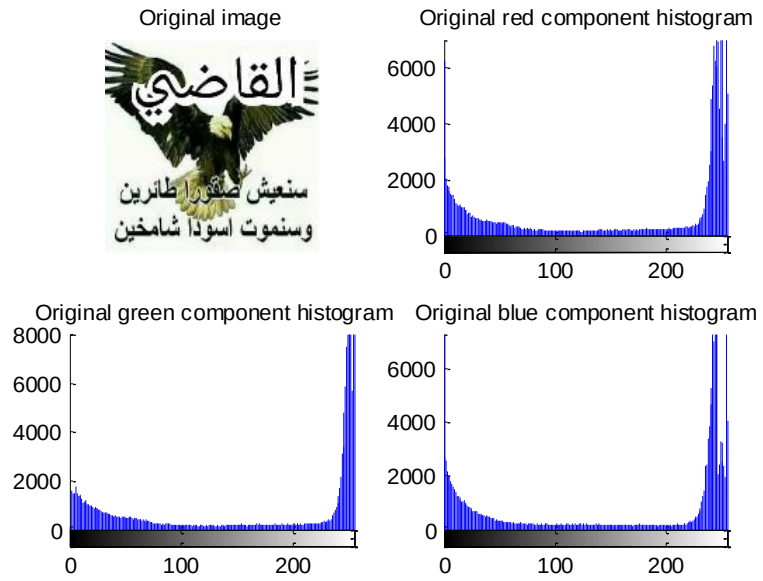

Figure (3): Original image

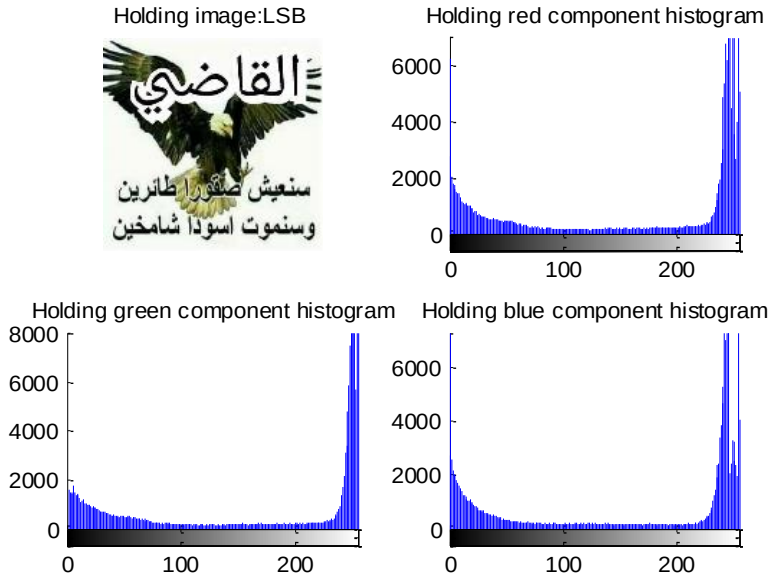

Figure (4): Holding image using LSB method

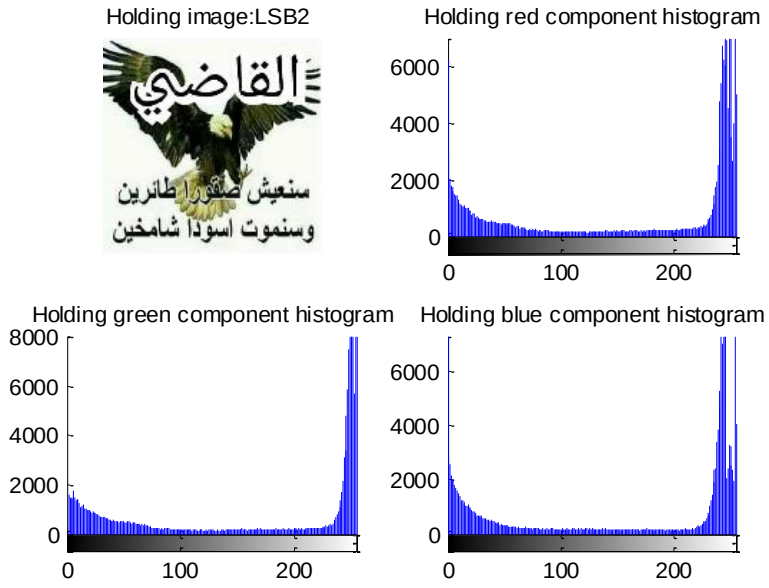

Figure (5): Holding image using LSB2Z method

Experiment 1:

A message of 26 character message "ABCDEFGHIJKLMNOPQRSTUVWXYZ" (short message) was selected and hidden in various images using LSB and LSB2Z methods.

Table (6) shows the results of this experiment:

From the obtained results obtained shown in table (6) we can raise the following facts concerned the short message hiding:

- LSB2 is more efficient by decreasing the hiding and extraction times.
- LSB2Z does not destroy the holding image by keeping high value of PSNR and this value is closed to LSB PSNR value.

Experiment 2:

Here we select a covering image with size equal 1144x1783x3=6119256 bytes to be used as a covering image for various in sizes messages (including huge size messages).

Figures (6), (7) and (8) show the covering and holding images after hiding a message with 53248 characters (huge message).

Also, looking to the holding image by eyes, it comes to us that these holding images are identical to the covering image.

The results of this experiment are shown in table (7)

Table (6): Experiment 1 results

Image size	LSB2Z			LSB		
	Hiding time(seconds)	Extracting time(seconds)	PSNR	Hiding time(seconds)	Extracting time(seconds)	PSNR
198x 254x3 =150876	0.001000	0.000001	176.0858	0.0250	0.0860	185.5239
160x 284x3 =136320	0.001000	0.000001	173.5233	0.0240	0.0670	184.5094
212x238x3 =151368	0.001000	0.000001	176.5341	0.0240	0.0700	185.5565
180x279x3 =150660	0.001000	0.000001	177.3231	0.0240	0.0670	185.5096
198x254x3 =150876	0.001000	0.000001	179.6125	0.0240	0.0670	185.5239
168x300x3 =151200	0.001000	0.000001	176.7617	0.0250	0.0680	185.5454
183x275x3 =150975	0.001000	0.000001	175.6932	0.0250	0.0680	185.5305
600x1050x3 =1890000	0.001300	0.000060	196.8241	0.2030	0.2560	210.8027
846x1504x3 =3817152	0.001700	0.000083	209.4928	0.3360	0.3610	217.8319
1144x1783x3 =6119256	0.003000	0.000107	213.2041	0.6680	0.6560	222.5513

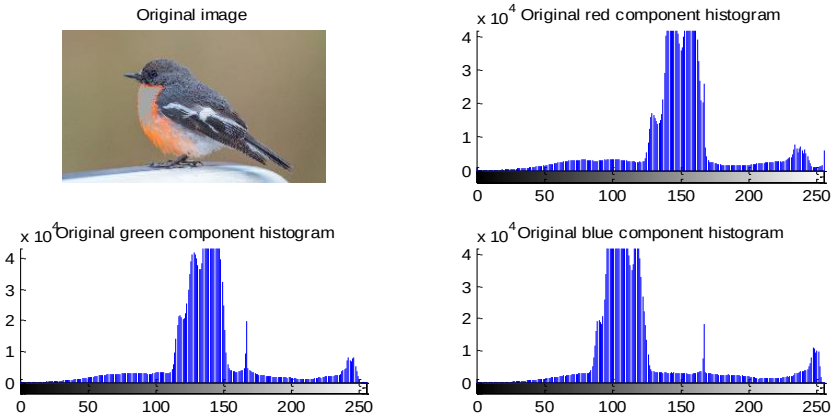

Figure (6): Covering original image with size = 6119256 pixels

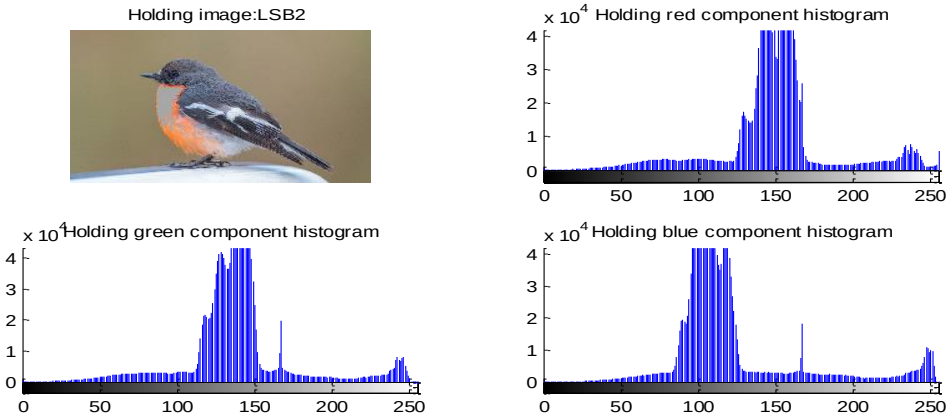

Figure (7): The same image holding a message with size= 53248 bytes using LSB2

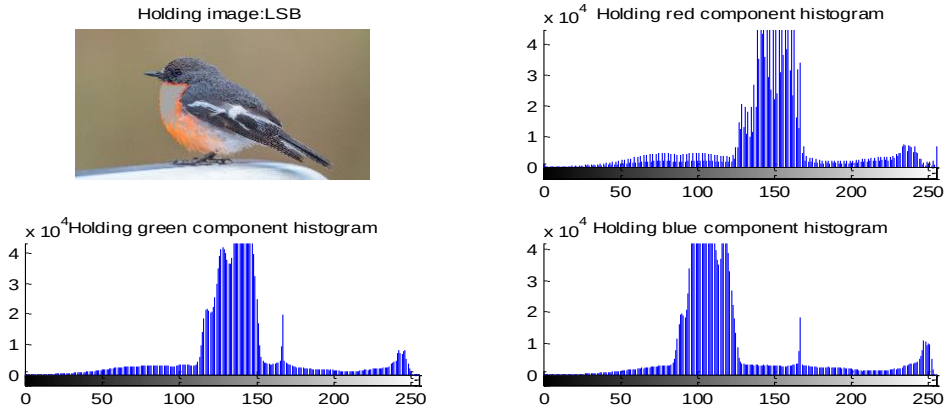

Figure (8): The same image holding a message with size= 53248 bytes using LSB

Table (7): Experiment 2 results

Message size(bytes)	LSB2			LSB		
	Hiding time(seconds)	Extracting time(seconds)	PSNR	Hiding time(seconds)	Extracting time(seconds)	PSNR
106496	0.988000	4.877000	129.4656	0.8100	0.7960	139.3736
53248	0.498000	1.564000	136.4519	0.7240	0.7160	146.3051
26624	0.292000	0.768000	143.3587	0.6970	0.6890	153.2366
13312	0.124000	0.353000	150.1587	0.6860	0.6690	160.1681
6656	0.063000	0.103000	157.0362	0.7470	0.6640	167.0995
3328	0.033000	0.031000	163.9282	0.6700	0.6520	174.0310
1664	0.018000	0.010000	170.9108	0.6560	0.6460	180.9625
832	0.010000	0.004000	177.9445	0.6480	0.6451	187.8939
416	0.006000	0.001000	185.1111	0.6340	0.6410	194.8254
208	0.004000	0.001000	191.9413	0.6120	0.6270	201.7569
104	0.003000	0.000012	198.7860	0.6110	0.6250	208.6884

From table (7) we can see that PSNR values of LSB2Z method are closed to LSB method values and the required times for hiding short messages Using LSB2Z method are better than the times provided by LSB method, as shown in figure (9)

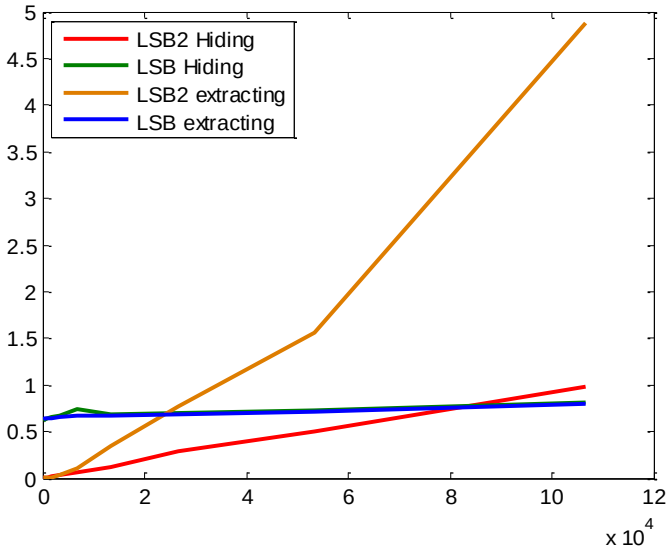

Figure (9): Time comparisons

Conclusion

A proposed methodology of data steganography was proposed, tested and implemented. LSB2Z and LSB methods are close in competency. LSB2Z method doubles the maximum size of the message to hidden in a covering image.
It was shown that LSB2Z method can be used to hide short messages and big messages without affecting or distorting the covering image by providing a high PSNR value, and maintains efficiency factors closed or better than LSB efficiency factors.

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