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Image Steganography Using DNA Sequence and Sudoku Solution Matrix

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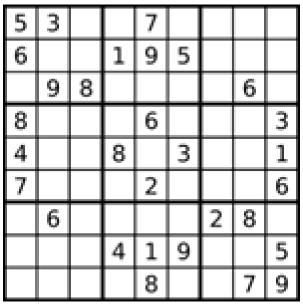
Abstract— **In this paper we are presenting a lossless image steganography approach. In steganography cover image is distorted due to strganographycal process. But according to the proposed method cover image will not be changed at all after implementation of staganography approach. To accomplish our approach DNA sequencing, Sudoku solution matrix and (t, n)-threshold sharing system are used. DNA sequencing is used to represent secret image by minimum no. of bits and Sudoku solution matrix represents the cover image. Here 16×16 Sudoku solution matrix is used and matrix is divided into 4×4 blocks. Secret image is embedded into cover image by camouflaging process. Camouflaging is done by (t, n)-threshold sharing system.**

Keywords— **Steganography, Cover image, Secret image, Camouflage, DNA, Sudoku, and Compression**

I. INTRODUCTION

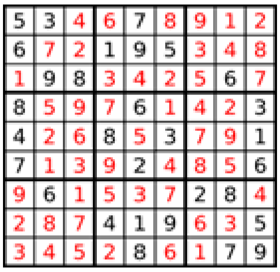
The term Steganography comes form the Greek words stegos (cover) and graphy (write). Therefore steganography literally means covered writing. Steganography unlike cryptography, does not change or scramble the message until it is illegible for an illegitimate receiver, it camouflages the message to occult its existence [2].

Sudoku, English pronunciation soo-DOH-koo is a logic-based, combinatorial number-placement puzzle. The proposed method derives the secret data and generates the meaningful image steganography using DNA sequence and sudoku .The objective of this game is to filled a 9×9 grid with the digits so that each of column, each of row, and all of the nine 3×3 sub-grids that compose of the grid contains all of the digits from 1 to 9. A partially completed grid produced by the puzzle setter which typically has a unique solution. For example, the same single integer may not appear twice in the same 9×9 playing board row or column or in any of the nine 3×3 sub regions of the 9×9 playing board [3]. Figure 1 shows a puzzle and Figure 2 indicates its solution.



5	3			7				
6			1	9	5			
	9	8					6	
8				6				3
4			8		3			1
7				2				6
	6					2	8	
			4	1	9			5
				8			7	9

Fig-1: A Puzzle [3]



5	3	4	6	7	8	9	1	2
6	7	2	1	9	5	3	4	8
1	9	8	3	4	2	5	6	7
8	5	9	7	6	1	4	2	3
4	2	6	8	5	3	7	9	1
7	1	3	9	2	4	8	5	6
9	6	1	5	3	7	2	8	4
2	8	7	4	1	9	6	3	5
3	4	5	2	8	6	1	7	9

Fig-2: Solve Puzzle [3]

DNA sequence, the information in DNA possess some interesting properties which can be utilized to hide data as a code prepared up of four chemical bases (A,C,G,T) : adenine (A), guanine (G), cytosine (C), and thymine (T). Conventionally, data hiding approaches frequently implant a secret message into the congregation images. However, this could deform the congregation image to some degree, and may therefore; medicinal effectiveness and susceptibility for solving complex, highly comparable computational problems have also been demonstrated. The capability to hide, gloss information, and watermarks within this intermediate is clearly meaningful. The order, or sequence, of these bases determines the information accessible for structuring and preserving an organism, comparable to the technique in which correspondence of the alphabet come into vision in a certain categorize to form sentence and words. DNA bases join up with both together, A with T and C with G, to configure units called base pairs that can promote greatly from a data hiding scheme, and a bit of surroundings in retroviral DNA sequences is required to understand this method. Each base is also closed to a sugar molecule and a phosphate molecule [4].

In this paper we propose a lossless staganography method in which DNA sequence is used to represent secret image. DNA sequence is converted into decimal form by Methodology-I or Methodology-II or Methodology-III or Methodology-IV. In the proposed method the secret image is hidden by the cover image using camouflaging procedure. Equal size Sudoku solution matrix of cover image is used to achieve proper camouflaging. Lagrange's interpolation equation is used to recover secret image from cover image.

The paper is organized as follows. In the next section we will discuss about related work. In Section 3, presenting flow diagram of staganography method .Section4, Details of the algorithm of camouflaging process. Section 5, Reverse procedure .Section 6, Example and Section 7, containing Conclusion.

II. RELATED WORK

The (t, n) Sharing Procedure

Let S be a shared secret image produced by a series of bit streams. Contribute to the secret S with Sudoku; the new methods lengthen the dimension of a Sudoku grid to 16×16 to enhance the secret capability. Besides, to suit the implanted procedure, the Sudoku grid packed with the digits from 0 to 15. Figure 3 reveal an example of a 16×16 Sudoku grid with the digits from 0 to 15. In the beginning, the planned sharing scheme, the merchant has to assign a exclusive key K_i to every element, where i =1, 2, …, n. In the accumulation, assume that O is the grayscale congregation image with H×W pixels. The pre-process is listed as follows.

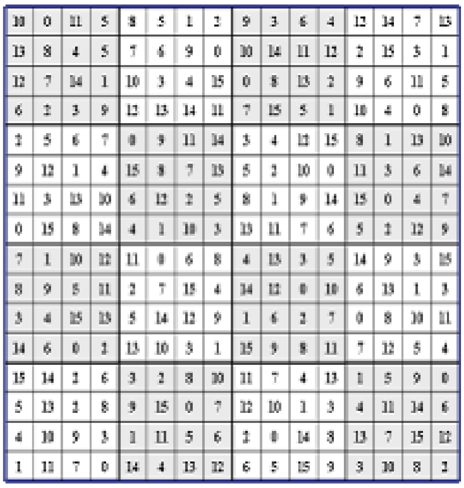
Step 1. Pair each pixel in O. That is, there are (H×W)/2 pixel pairs.

Step 2. Generate a matrix M with the size of H×W. Here, M is consisted of Sudoku grids with the size 16×16, as shown in Fig. 4.

Step 3. separate the secret bit pattern S into no overlapping section with 4 bits, where

$S = (s_1, s_2, \ldots, s_m) \bmod 16$. Here, s_1, s_2, s_m are the base-16 numeral system digits.

For the occurrence, when the secret bit pattern is $(1010\ 0011)_2$, we can subdivision the pattern into two digits $(10, 3)_{16}$. In the new method, as an alternative of implant one secret pixel into the polynomial F(x) , the new method implant (t-1) secret digits into F(x). These enlarge the capability of the implanted secret data. For expediency, suppose that the shared (t-1) digits of S are $s_1, s_2, \ldots s_{t-1}$. [1]



10	0	11	5	8	5	1	2	9	3	6	4	12	14	7	13
13	8	4	5	7	6	9	0	10	14	11	12	2	15	3	1
12	7	14	1	10	3	4	15	0	8	13	2	9	6	11	5
6	2	3	9	12	13	14	11	7	15	5	1	10	4	0	8
2	5	6	7	0	9	11	14	3	4	12	15	8	1	13	10
9	12	1	4	15	8	7	13	5	2	10	0	11	3	6	14
11	3	13	10	6	12	2	5	8	1	9	14	15	0	4	7
0	15	8	14	4	1	10	3	13	11	7	6	5	2	12	9
7	1	10	12	11	0	6	8	4	13	3	5	14	9	3	15
8	9	5	11	2	7	15	4	14	12	0	10	6	13	1	3
3	4	15	13	5	14	12	9	1	6	2	7	0	8	10	11
14	6	0	2	13	10	3	1	15	9	8	11	7	12	5	4
15	14	2	6	3	2	8	10	11	7	4	13	1	5	9	0
5	13	2	8	9	15	0	7	12	10	1	3	4	11	14	6
4	10	9	3	1	11	5	6	2	0	14	8	13	7	15	12
1	11	7	0	14	4	13	12	6	5	15	9	3	10	8	2

Fig-3: Instance of 16×16 Sudoku grid

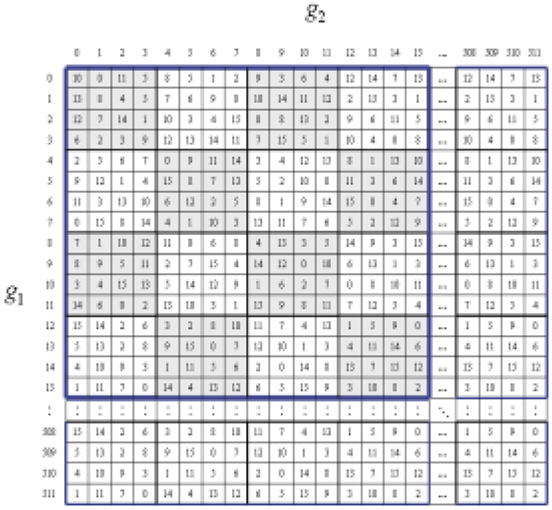


Fig-4: Instance of 512×512 matrix M using the digits from 0 to 15. [1]

Algorithms for DNA sequence conversion of an image

Methodology I [5]

Step 1. Take a DNA sequence.

Step 2. This DNA sequence assign as a DNA sequence of an image.

Step 3. Four nucleotides in DNA sequence (A,C,G,T), 2 bit is used to represent 4 nucleotides.
Like 00 for A, 01 for C, 10 for G and 11 for T.

Step 4. Represent DNA sequence in digital form D.

Step 5. D is the compress binary form of that image.

Methodology II [5]

Step 1. Take a DNA sequence.

Step 2. This DNA sequence assign as a DNA sequence of an image.

Step 3. Compress DNA sequence using -1) 2-bits encoding method, 2) Exact matching Method, 3) Approximate matching method, 4) For the approximate matching method, One of the methods will produce minimum no. of bits.

Methodology III [6]

Algorithm-I

Step 1. Scan Secret image from left to right, starting from upper left corner.
Step 2. Take one pixel at a time.
Step 3. Get the colour code of the pixel.
IF colour code (cc) in Hexadecimal then go to Step-5.
Step 4. Convert colour code (cc) in Hexadecimal.
Step 5. R = (cc&OxFF0000)>>16,
G = (cc&Ox00FF00)>>8,
B = (cc&Ox0000FF).
Step 6. Store R, G, B value of each pixel in Table-1.Table-1 contains each pixel
Position and corresponding R, G, B value of Secret image.
Step 7. Repeat Step-1 to 6 until reach lower right corner of Secret image.
Step 8. End.

Algorithm-II

In case of 8 bit image, maximum no of colours can generate is 256 for R, G and B. Possible nucleotides are A, C, G, T. Hence, there are 4^4=256 combinations required to represents R, G and B.Similarly for 16 bit image maximum no of colours is 65636.Then 8 nucleotide combination used to represent R, G and B.

Step 1. Draw Table-2, which contain 0 to 255 no and corresponding DNA combination.
Step 2. Get the DNA sequence of each pixel's R, G, and B value from Table-1 and Table-2.
Step 3. Repeat Step-2 until reach the last pixel.
Step 4. End.

Algorithm-III

Step 1. Take the Secret Image.
Step 2. Find out DNA sequence of Secret Image by using Algorithm I and II.

TABLE - 1

THE OUTPUT OF THE SECRET IMAGE WILL BE STORED IN THE TABLE I AS THE OUTCOME OF ALGORITHM I.

Pixel Position (X,Y)	**R value**	**G value**	**B value**

TABLE-2

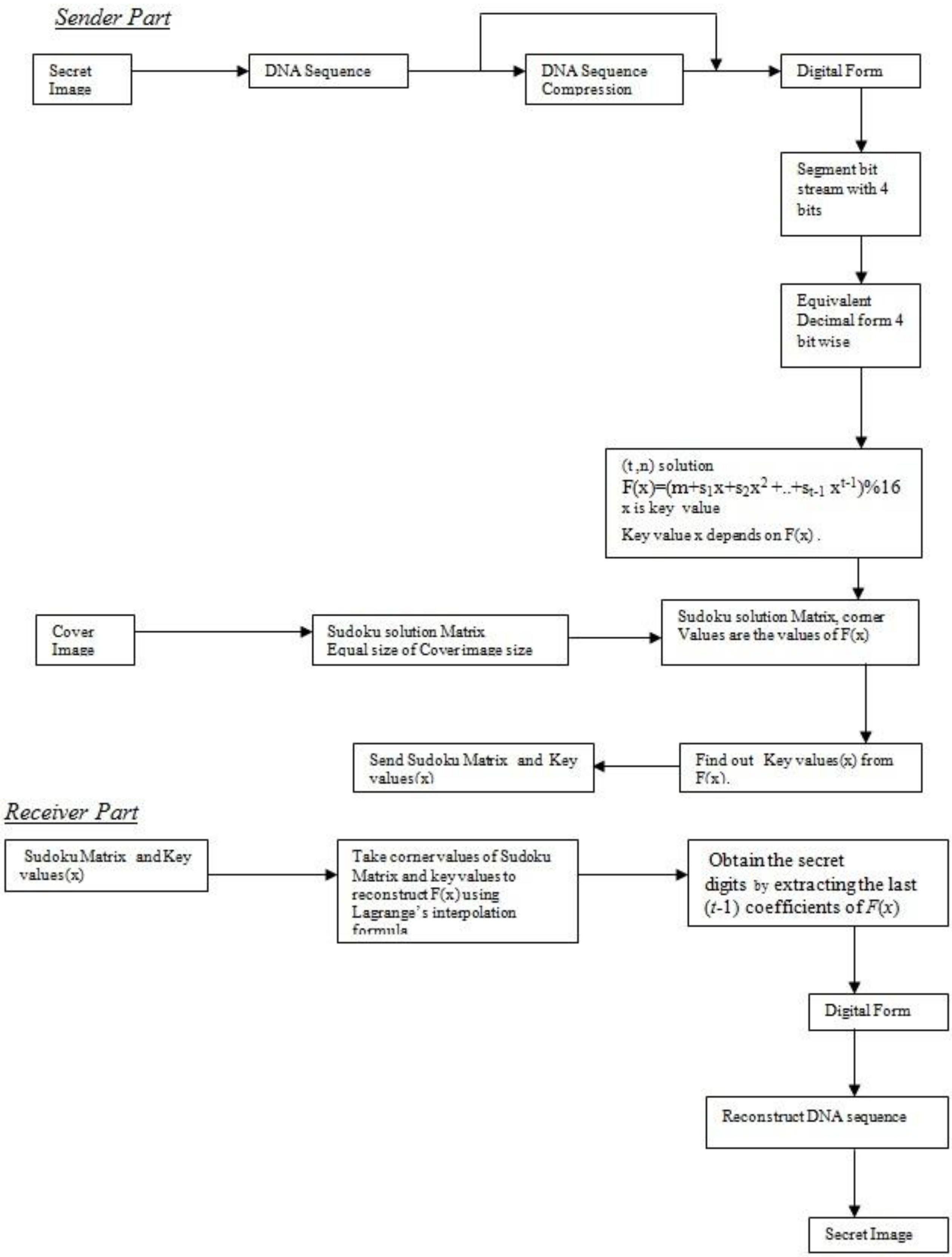
IN TABLE-2 DNA COMBINATION CHOSEN RANDOMLY FOR CC NO WHICH MAKES OUR METHOD MORE SECURE AND RELIABLE

CC	**DNA Combination**	**CC**	**DNA Combination**	**CC**	**DNA Combination**	**CC**	**DNA Combination**	**CC**	**DNA Combination**
0	AAAA	9	ATAA	18	CCGC	27	GGGA	36	AGGG
1	AAAC	10	CAAA	19	CCTC	28	GGGC		
2	AAAG	11	GAAA	20	CACC	29	GGGT		
3	AAAT	12	TCCC	21	CGCC	30	GGAG		
4	AACA	13	CCCC	22	CTCC	31	GGCG		
4	AAGA	14	CCCA	23	ACCC	32	GGTG		
6	AATA	15	CCCG	24	GCCC	33	GAGG		
7	ACAA	16	CCAT	25	TCCC	34	GCGG		
8	AGAA	17	CCAC	26	GGGG	35	GTGG	255	ACGT

Methodology IV [4]

Step 1. Choose an arbitrary mRNA sequence for binary sequence of an image.
Step 2. Convert mRNA sequence into amino acid sequence.
Step 3. Use Arithmetic encoding. Arithmetic encoding will convert amino acid sequence into an interval of real numbers between 0 and 1.
Step 4. Get the corresponding binary form.

III. IMAGE HIDING SCHEME



IV. SHADOW GENERATION METHOD

Select any pixel pair from any 4×4 Sudoku grid .Let g_a and g_b be the selected pixel pair. Where g_a and g_b is the row and colum wise pixel position respectively. The advantage of using reversible sharing for share the secret digits s_1, s_2 ,…, s_{t-1} to retain the original values of pixel position ($g_{a,}$ g_b).

Step 1. Learn the value m of the Sudoku digit by mapping the row g_a and column g_b at a matrix M, where m = M (g_a, g_b)

Step 2. Formulate an invertible polynomial F(x) as $F(x) = (m+s_1x^1+s_2x^2+\ldots\ldots\ldots\ldots\ldots +s_{t-1}\,x^{t-1}) \bmod 16$.

Step 3. Generate n shadows y_i's which are the corner values of Sudoku matrix.

Step 4. Find out key K_i from F(x), where $y_1 = F(K_1)$, $y_2 = F(K_2)$, …, and $y_n = F(K_n)$.

V. REVERSE PROCEDURE

Using the value of key's and corner values of Sudoku matrix in Lagrange's interpolation equation, receiver can reconstruct F(x).From F(x) receiver can obtain the secret digits s_1, s_2, s_3,………………….., s_{t-1}.

VI. EXAMPLE

Fig-5: Cover Image

Fig-6: Secret image

For cover image Sudoku solution matrix is fig-5.

Using Methodology IV, mRNA sequence of secret image (Fig-6) is "CUU CCG UGC GAU GUA GCC GGU AUC UUU GGA CAU UGG UAU AUU UCA UGC" which is chosen arbitrarily .Arithmetic encoding convert this mRNA sequence in decimal form is 0.272850788.

Equivalent binary form 0. 01000111.

Segmenting the bit stream in 4 bit segment, 0100, 0111.

Converting bit stream segment in decimal form 4, 7.

Selected pixel pair for embedding bit stream in Sudoku matrix is (6, 7).So, value of m is 10.

Thus, F(x) can be formulated as

$$F(x) = (m+S_1x^1+S_2x^2) \bmod 16.$$
$$= (10+4x+7x^2) \bmod 16.$$

Camouflaging

1st corner value of Sudoku matrix in pixel position (0, 0) is 10. This is the 1st shadow Image (O_1).

Thus

$$10=F(x)$$
$$= (10+4x+7x^2) \bmod 16$$

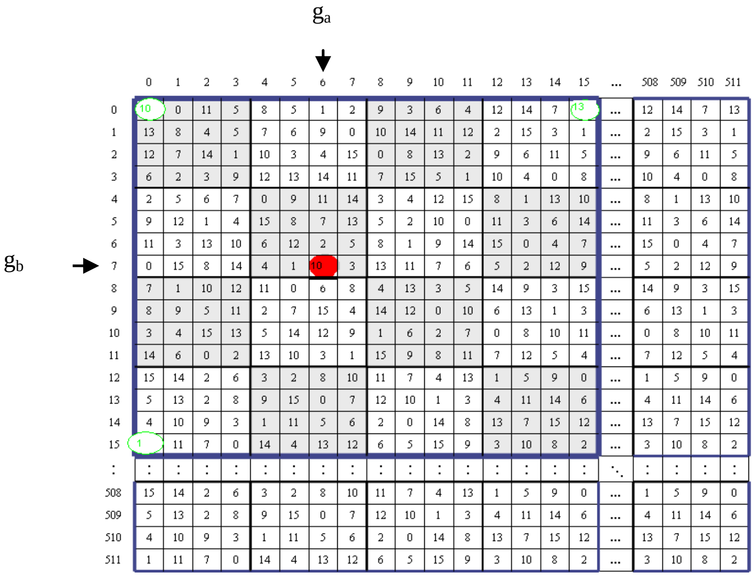
From the above equation we will get x=1.22, is the 1st key value k_1.

2nd corner value of Sudoku matrix in pixel position (0, 15) is 13.This is the 2nd Shadow image (O_2). Similarly x=1.38, is k_2.

3rd corner value of Sudoku matrix in pixel position (15, 0) is 1.This the 3rd Shadow image (O_3) and x=0.75, is k_3.

By repeating the shadow derivation and camouflage process, the sender can generate and camouflage all secret shadows into the host pairs in order to obtain n shadow images O_i's and corresponding key k_i's.Figure-7 showing camouflage processes.

Send Sudoku matrix and key values 1.22, 1.38, 0.75.



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	...	508	509	510	511
0	10	0	11	5	8	5	1	2	9	3	6	4	12	14	7	13	...	12	14	7	13
1	13	8	4	5	7	6	9	0	10	14	11	12	2	15	3	1	...	2	15	3	1
2	12	7	14	1	10	3	4	15	0	8	13	2	9	6	11	5	...	9	6	11	5
3	6	2	3	9	12	13	14	11	7	15	5	1	10	4	0	8	...	10	4	0	8
4	2	5	6	7	0	9	11	14	3	4	12	15	8	1	13	10	...	8	1	13	10
5	9	12	1	4	15	8	7	13	5	2	10	0	11	3	6	14	...	11	3	6	14
6	11	3	13	10	6	12	2	5	8	1	9	14	15	0	4	7	...	15	0	4	7
7	0	15	8	14	4	1	10	3	13	11	7	6	5	2	12	9	...	5	2	12	9
8	7	1	10	12	11	0	6	8	4	13	3	5	14	9	3	15	...	14	9	3	15
9	8	9	5	11	2	7	15	4	14	12	0	10	6	13	1	3	...	6	13	1	3
10	3	4	15	13	5	14	12	9	1	6	2	7	0	8	10	11	...	0	8	10	11
11	14	6	0	2	13	10	3	1	15	9	8	11	7	12	5	4	...	7	12	5	4
12	15	14	2	6	3	2	8	10	11	7	4	13	1	5	9	0	...	1	5	9	0
13	5	13	2	8	9	15	0	7	12	10	1	3	4	11	14	6	...	4	11	14	6
14	4	10	9	3	1	11	5	6	2	0	14	8	13	7	15	12	...	13	7	15	12
15	1	11	7	0	14	4	13	12	6	5	15	9	3	10	8	2	...	3	10	8	2
:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	⋱	:	:	:	:
508	15	14	2	6	3	2	8	10	11	7	4	13	1	5	9	0	...	1	5	9	0
509	5	13	2	8	9	15	0	7	12	10	1	3	4	11	14	6	...	4	11	14	6
510	4	10	9	3	1	11	5	6	2	0	14	8	13	7	15	12	...	13	7	15	12
511	1	11	7	0	14	4	13	12	6	5	15	9	3	10	8	2	...	3	10	8	2

Fig-7: Instance of camouflage results

VII. CONCLUSION

This paper we are presenting a lossless image steganography approach. To accomplish our approach DNA sequencing, Sudoku solution matrix and (t, n)-threshold sharing system are used. DNA sequencing is used to represent secret image by minimum no. of bits and Sudoku solution matrix represents the cover image.

VIII. REFERENCE

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