Implementation of Variable Least Significant Bits Stegnography using DDDB Algorithm

Sahib Khan[1], Muhammad Haroon Yousaf[2] and Jamal Akram[3]

[1] **Department of Telecommunication Engineering, University of Engineering and Technology, Taxila Taxila, Punjab 47080, Pakistan**

[2] **Department of Computer Engineering, University of Engineering and Technology, Taxila Taxila, Punjab 47080, Pakistan**

[3] **Department of Electrical Engineering, Federal Urdu University, Islamabad Islamabad, 44000, Pakistan**

Abstract

Nobody can deny the importance of secure communication. Different techniques are being utilized to achieve this task. Image Stegnography is one such method in which we hide data in an otherwise ordinary image. In this paper, a novel Stegnographic technique named as Variable Least Significant Bits Stegnography (VLSB) is proposed. To implement VLSB, we designed an algorithm named as Decreasing Distance Decreasing Bits Algorithm (DDDBA). In each test we performed, the data hiding capacity was always greater than 50 % (a barrier considered in image Stegnography), ranging up to 69 % with signal to noise ratio varying from 10 db to 5 db respectively. The DDDBA provides self-encryption mechanism in VLSB Stegnography, making the Steganalysis more difficult.

Keywords: *VLSB Stenography, DDDB Algorithm, Steganalysis, Key Size, Signal to Noise Ratio, Hiding Capacity.*

1. Introduction

The word ‘Stegnography’ literally means covered writing. It is a technique to camouflage the required information underneath an otherwise innocuous & routine data, in inconspicuous ways. Stegnography hides the covert information within the cover medium [1] making it difficult for anyone to detect even the presence of behind the scene secret message [2].

Stegnography is increasingly becoming popular especially in Defense Sector because of its distinctive features. In World War II, the first military use of Stegnography was seen and invisible inks were used for writing messages in between the lines of normal text message [3]. Germans in World War II used microdots. In this technology, the size of secret message containing photographs was reduced by a period. FBI director J. Edgar Hoover [4] called this technology “the enemy’s master piece of espionage”. With the development of digital images, new era of Stegnographic research started with multiple applications such as copyright protection, watermarking, fingerprinting, and Stenography [5, 7, 15 and 16]. Simmons’ formulation of the Prisoners’ Problem was itself an example of information hiding [8], [9].

Generally, information-hiding techniques are divided into two main categories: techniques in transform domain (e.g. Discrete Cosine Transform (DCT) [10] & Discrete Wavelet Domain [11] [12]), and techniques in time domain or spatial domain (e.g. LSB Stegnography, 4LSB Stegnography method [6]). 4LSB Stegnography has fixed data hiding capacity of 50% i.e. we need a cover file of almost double size as that of message file. To overcome this barrier, without compromising on security, a new technique called Variable Least Significant Bits (VLSB) Stegnography is devised. More details of data embedding and watermarking methods are available in [13]. Additional readings, software, and resources used in researching Stegnography and digital watermarking are available at [14].

2. VLSB Stegnography

Besides having a fixed limit of 50% data hiding capacity, 4LSB is relatively insecure as everyone can guess the position of actual data [17]. VLSB Stegnography, on the other hand has variable amount of data hidden in every individual pixel or group of pixels of the cover image. Cover image is divided in various groups of pixels, with each group being termed as a sector. The size of the sector is variable, ranging from the size of a complete cover file to that of a single pixel. Then, a specific number of bits “Bi”, of each individual pixel of a sector, are used for data hiding. The numbers of bits, used for substitution, varies from sector to sector according to a predefined algorithm.

The division of cover image into various sectors is the most crucial step for the implementation of VLSB Stegnography. The algorithm proposed should be capable of providing larger hiding capacity with least possible distortion. This will open a new research area for the researchers to play with VLSB Stegnography.

3. DDDB Algorithm

Decreasing Distance Decreasing Bits Algorithm (DDDBA) is a distance-based technique developed to implement VLSB Stegnography. First, the cover image is divided into various numbers of sectors on the basis of the distance of a pixel or group of pixels with respect to a specific reference point, usually the central pixel. The number of bits to be substituted in each pixel of a sector is decided on the basis of distance of that particular sector from the reference pixel. As the distance decreases, the number of bits to be embedded also decreases. That is why it is called Decreasing Distance Decreasing Bits Algorithm. The number of sectors "Ns" and the number of bits "Bi" to be substituted, play a vital role in determining hiding capacity, SNR/Distortion and key size. Large number of sectors results in small sector size, low distortion, large SNR and smaller hiding capacity and vice versa. By increasing the number of sectors to infinity, the sector size tends to zero and the whole cover file is treated as a single sector by the proposed algorithm; and for this particular case the VLSB Stegnography becomes equivalent to 4LSB Stegnography

2.1 Hiding Capacity of DDDB Algorithm

Decreasing According to DDDB Algorithm, the cover image is divided into "Ns" number of sectors, each of size "S_{zi}". Then "B_i" number of bits is hidden in each individual pixel of sector "Si". Therefore, the total number of bits "Di" hidden in sector "S_i" of size "S_{zi}" is given by

$$D_i = S_{zi} \times B_i \tag{1}$$

The total amount of data "D_{total}" hidden in the cover image can be calculated as:

$$D_{total} = \sum_{i=1}^{Ns} D_i \tag{2}$$

The hiding capacity "C" can be found by:

$$C = \frac{D_{total}}{B_{total}} \times 100 \tag{3}$$

$$C = \frac{\sum_{i=1}^{Ns} D_i}{N \times 8} \times 100 \tag{4}$$

$$C = \frac{\sum_{i=1}^{Ns} (S_{zi} \times B_i)}{N \times 8} \times 100 \tag{5}$$

Obviously, to get a data hiding capacity of more than 50% B_i should be greater than or equal to 4.

2.2 Key Size of DDDB Algorithm

As mentioned in the previous section, DDDB Algorithm divides the cover image into "Ns" number of sectors. Then each sector can be used to hide a number of bits "B_i" ranging from 0 to 8 (0≤ B_i ≤8) i.e. we have 9 possibilities for each sector. Therefore, the total possible ways (Key Size) to implement VLSB Stegnography using DDDB Algorithm is given by:

$$KeySize = N_s \times C_1^9 \quad \text{for } 0 \le B_i \le 8 \tag{6}$$

$$KeySize = N_s \times 9 \tag{7}$$

However, for 0≤ B_i ≤8 the data hiding is smaller the 50%. To get a data hiding capacity which is greater than 50%, B_i should be greater than or equal to 4 i.e. 4≤ B_i ≤8. For this range, we are having 5 different values of B_i so the Key Size for more than 50% data hiding capacity will be

$$KeySize = N_s \times C_1^5 \quad \text{for } 4 \le B_i \le 8 \tag{8}$$

$$KeySize = N_s \times 5 \tag{9}$$

Therefore, the capacity is increased at the cost of reduced Key Size.

2.3 SNR and PSNR of DDDB Algorithm

The quality of the stego-image is measured quantitatively by calculating signal to noise ratio (SNR) and peak signal to noise ratio (PSNR).

SNR and PSNR for a stego image are calculated in Decibels as:

$$SNR = -10 Log\left[\frac{sum((Coverimage - Stegoimage)^2}{sum((Coverimage)^2)}\right]^{-1} \tag{10}$$

$$PSNR = -10 Log\left[Mean((Coverimage - Stegoimage)^2)\right] \tag{11}$$

4. Implantation

In DDDB algorithm point, usually the centre pixel is selected as a reference. Then the maximum distance between the central pixel and border pixels is determined. The cover image is divided into a number of sector (Ns) each of Size (Sz). Each sector of cover image is assigned a specific number of bits "Bi" to be embedded in each pixel of that sector. The number of bits used for data hiding varies from sector to sector based on its distance from the central pixel. According to DDDB Algorithm, the number bits to be substituted decreases with decreasing distance of the pixel from the centre of the cover image. There are three types of distances; Euclidean, Chess Board and City Block. Each of the three can be used for implementing VLSB Stegnography using DDDB Algorithm. As shown in figure 1.

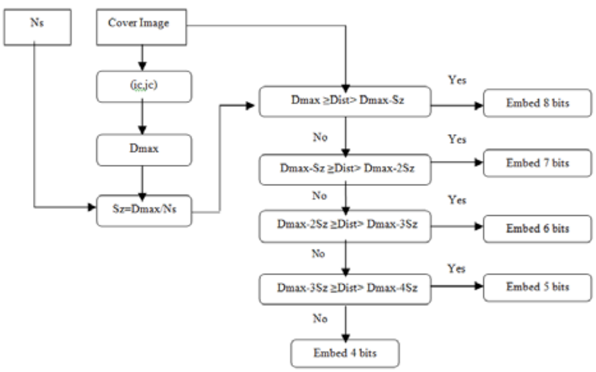


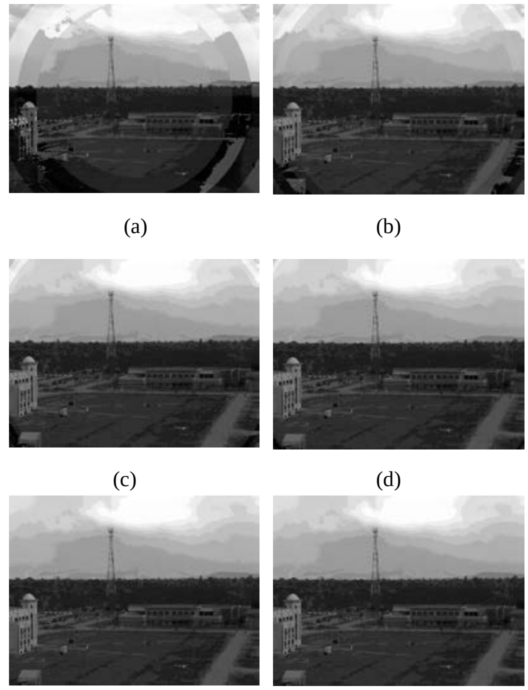
Fig. 1 Block Diagram of DDDB Algorithm

5. Experimental Results

Both the Qualitative, as well as the quantitative analysis of VLSB Stegnography using DDDBA was done, results were obtained & then analyzed. The experimental results using Euclidean, Chess Board and City Block distance are shown and compared in the following sections. However, the results obtained by using city block distance are not that much significant due to noticeable distortion and that too with less hiding capacity.

5.1 DDDB Algorithm with Euclidean Distance

Variable Least Significant Bits Stegnography implemented using Decreasing Distance Decreasing Bits Algorithm with Euclidean distance [18 and 19] and the resulted stego images for varying number sectors "Ns" and sector size "S_z" are obtained. The resulted stego images for Ns= 8, 16, 32, 64 and ∞ are shown here in figure 2 (a, b, c, d and e) respectively and the stego image obtained from 4SLB Stegnography is shown in figure 2(f).



(a) (b)
(c) (d)
(e) (f)

Fig. 2: (a)-(e) show five stego images obtained by implementing VLSB Stegnography using DDDB Algorithm for different number of sectors "Ns=8,16,32,64 and ∞"; (f) shows the stego image obtained by using 4LSB Stegnography

Quantitative data of hiding capacity, SNR and PSNR is shown in table 1. When we increase the number of sectors, both hiding capacity and distortion decreases. When the cover file is divided into infinite number of sectors, the VLSB Stegnography using devised Algorithm becomes equivalent to 4LSB Stegnography. The data hiding capacity and distortion created using both the techniques become equal. The result is shown in figure 2 (f, e).

It is apparent from table 1 that hiding capacity of VLSB Stenography using DDDB algorithm is always higher than or equal to 4LSB Stegnography. Signal to noise ratio and peak signal to noise ratio are also affected by the number of sectors. SNR increases with increasing number of sector and vice versa.

Table 1: Hiding Capacity, SNR and PSNR of DDDB Algorithm with Euclidean Distance

Sr. No	Ns	Hiding Capacity	SNR	PSNR
1	8	64.6046	5.7902	-18.2743
2	16	53.8407	8.5163	-15.5482
3	32	50.8353	9.8855	-14.1790
4	64	50.1999	10.1694	-13.8951
5	Infinity	50.0000	10.2808	-13.7836
6	4LSB	50.0000	10.2808	-13.7836

5.2 DDDB Algorithm with Euclidean Distance

From Variable Least Significant Bits Stegnography is implemented with DDDB Algorithm using Chess Board distance [18] and results for varying number of sectors "Ns" and sector size "Sz" are obtained. The resulted stego images for Ns= 8, 16, 32, 64 and ∞ are shown in figure 3 (a, b, c, d and e) respectively. The stego image developed with 4LSB Stegnography is shown in figure 3(f). Quantitative data of hiding capacity, SNR and PSNR is shown in table 2.


(a)


(b)


(c)


(d)


(e)


(f)

Fig. 3: (a)-(e) show five stego images obtained by implementing VLSB Stegnography using DDDB Algorithm with Chess Board Distance for Ns=8,16,32,64 and ∞ respectively; (f) shows the stego image obtained by using 4LSB Stegnography

Table 2: Capacity, NSR and PSNR of DDDB Algorithm with Chess Board Distance

Sr. No	Ns	Capacity	SNR	PSNR
1	8	69.0926	5.1915	-18.8729
2	16	57.8509	7.8138	-16.2507
3	32	53.8966	8.9079	-15.1565
4	64	51.9387	9.4960	-14.5685
5	Infinity	50.0000	10.2808	-13.7836
6	4LSB	50.0000	10.2808	-13.7836

While increasing the number of sectors, both hiding capacity and distortion decreases. When the cover file is divided into infinite number of sectors, the VLSB Stegnography using devised Algorithm becomes equivalent to 4LSB Stegnography. The data hiding capacity and distortion created using both techniques become equal. The result is shown in figure 3 (a-f).

6. Conclusions

In this paper, VLSB Stegnography using DDDB Algorithm is being proposed to achieve image Stegnography with desired results. Due to variable bits substitution, variable amount of data is hidden in different sectors of cover image depending upon the distance from the reference point. More data is hidden in border pixels, creating more distortion at the boundary of stego image. Due to eyesight limitation and false perception, the distortion at the border creates no significant effect if the number of sectors is large. When the number of sectors is made equal to infinity, VLSB Stegnography using DDDB Algorithm and 4LSB Stegnography techniques became equivalent as shown in figure 2(e and f), figure 3(e and f), table 1 and table 2. Moreover, for the same number of sectors, greater hiding capacity can be achieved using chessboard distance as compared to the Euclidean distance in which lesser hiding capacity is available, though with minimum distortion. However, both can effectively be used for hiding capacity of 50% and more.

References

[1] S. Dumitrescu, W.X.Wu and N. Memon (2002), "On steganalysis of random LSB embedding in continuous-tone images", Proc. International Conference on Image Processing, Rochester, NY, pp. 641-644.
[2] S.K. Moon and R.S. Kawitkar (2007)," Data Security using Data Hiding", International Conference on Computational Intelligence and Multimedia Applications, pp.247-251.
[3] D. Kahn and Macmillan (1967),"the Codebreakers", New York.
[4] Beenish Mehboob and Rashid Aziz Faruqui (2008)," A Stegnography Implementation", IEEE.
[5] Kafa. Rabah (2004), "Steganography - The Art of Hiding Data", Information technology Journal 3 (3).
[6] J. Fridrich, M. Goljan, and R.Du (2001),"Detecting LSB Stegnography in Color and Gray –Scale Images", Magazine of IEEE Multimedia, Special Issue on Security, October-November issue, pp.22-28.
[7] T. Cedric, R. Adi and I. Mcloughlin (2000)," Data concealment in audio using a nonlinear frequency distribution of PRBS coded data and frequency-domain LSB insertion", Proc. IEEE International Conference on Electrical and Electronic Technology, Kuala Lumpur, Malaysia, pp. 275-278.
[8] Gustavus J. Simmons (1998), "How to insure that data acquired to verify treaty compliance are trustworthy," *Proc. IEEE*, vol. 76, p. 5.

[9] Gustavus J. Simmons (May,1998) , "The history of subliminal channels," IEEE Journal on selected areas in communication, vol. 16, no. 4, pp. 452–462.

[10]Chiou-Ting Hsu, Ja-Ling Wu (January, 1999)," Hidden Digital Watermarks In Images", IEEE Transaction on Image Processing, 8(1): 56-58.

[11]Nedeljko Cvejic, Tapio Seppanen (Oct 2002)," A Wavelet Domain LSB Insertion Algorithm For High Capacity Audio Steganography", Digital Signal Processing, workshop 2002 and the 2nd signal processing education workshop. Proceedings of 2002 IEEE, 10th, 13-16, Pages: 53-55.

[12]NI Ronggong, RUAN Qiuqi (Oct 2002),"Embedding Information into Color Images Using Wavelet, TENCON'02", Proceedings, 2002 IEEE Region 10 Conference on Computers, Communications, Control and Power Engineering, Volume:1, 28-31, pages: 589-601..

[13]M.D. Swanson, M. Kobayashi, A.H. Tewfii (June, 1998), "Multimedia Data-Embedding and Watermarking Technologies", *Proc. of the IEEE,* vol. 86, no. 6, pp. 1064-1087.

[14]M.D. Swanson, B. Zhy and A.H. Tewfik (1996), "Transparent robust image watermarking", *Proc.* IEEE *International Conference on Image Processing* (ICIP96), Piscataway, NJ. IEEE Press, vol. 3

[15]S. K. Moon, V. N. Vasnik, "Application of steganography on image file", National conference on Recent trends in Electronics, pp. 179-185.

[16]T. Morkel, J. H. P. Eloff, M. S. Olivier,"An Overview of Image Steganography", Information and Computer Security Architecture (ICSA) Research Group, Department of Computer Science, University of Pretoria, SA.

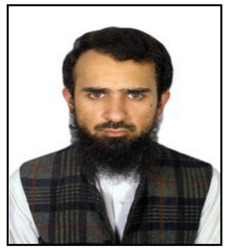
[17]Sahib Khan and M. Haroon Yousaf, " Variable Least Significant Bits Stegnography", Accepted in IJCSI, 2011 (To be published)

[18]R.C. Gonzalez, R.E. Woods. *Digital Image Processing.* 2nd Ed, Prentice-Hall, Upper Saddle River, New Jersey, 2002.

[19] xlinux.nist.gov/dads/HTML/euclidndstnc.html

Engr. Sahib Khan is pursuing M.Sc in Telecommunication Engineering at department of Telecommunication Engineering, Faculty of Telecommunication and Information Engineering, University of Engineering and Technology Taxila. He has B.Sc Telecommunication Engineering from N-W.F.P University of Engineering and Technology Peshawar, Pakistan. He is serving as a Lecturer and Course Coordinator at department of Electrical and Computer Engineering, Kohat University of Science and Technology Kohat, Pakistan. His areas of interest are Digital Image Processing and Data Authentication and Information Security.

Engr. Muhammad Haroon Yousaf is pursuing Ph. D. in Computer Engineering at University of Engineering & Technology Taxila, Pakistan. He got M.Sc. and B.Sc. in Computer Engineering in the years 2007 and 2005 respectively. He currently holds the position of Assist Prof in the Faculty of Telecommunication & Information Engineering. His research interests include gesture and activity recognition, human computer interaction, computer vision and machine learning. He, along with his students, is investigating face recognition based solution for automated attendance management system.



Engr. Jamal Akram has done BSc Electrical Engg with Honours from University of Engg & Technology, Peshawar in 2000. He did his Masters in Computer Engg from University of Engg & Technology, Taxila in the year 2008. He has worked for more than 10 years in National Fertilizers Corporation & Pakistan Telecommunications Company Ltd. His areas of interest include Image Processing, Information Security, computer-vision and antenna design. Currently he is faculty member of Federal Urdu University Islamabad. He is also a member of IEEE.