The Effect of Various Number of Least Significant Bits substitution in Audio using Discrete Cosine Transform

Sahib Khan[1], Umar Said[2], Ejaz Ahmad[3], Fazlullah[4]and Mukhtair Ali[5]

[1-5] Dept. of Electrical Engineering, University of Engineering and Technology, Peshawar, Pakistan

Abstract

A secure exchange of information is the need of today's digital world, achieved by either changing the shape of information according to a predefined key using cryptography or concealing the information in a cover media, in spatial or transform domain, using Stegnography. The hiding data in various least significant bits of DCT coefficients of an audio cover file is the subject of this work. This paper statistically analyze the effect of different number of least significant bits (LSB) on Stego audio in terms of signal to noise ratio (SNR), peak signal to noise ratio (PSNR), mean square error (MSE) and data hiding capacity. The hiding capacity increases significantly with the increase in the number of least significant bit substituted with information bits and results in a very insignificant variation in SNR, PSNR and MSE. The statistical analysis shows that audio Stegnography in DCT domain is subjected to more distortion at lower hiding capacity and is subject to almost the same distortion for large data hiding capacity.

Keywords: *Audio Stegnography, Discrete Cosine Transform, Watermarking, Information Security, Steganalysis*

1. Introduction

The infrastructure for distribution of digital media has grown rapidly. This provides an excellent opportunity. There for we have so many methods for data hiding i.e. Stegnography, cryptography, watermarking. Stegnography is a technique used for hiding information in a cover media such as audio, video, text and image. In both temporal (LSB, VLSB) [1, 2, 3] and transform domain (DCT, DWT) [1]. The common methods that are used for data hiding in temporal domain are LSB and VLSB [3, 4]. In transform domain, we can hide data by using Discrete Wavelet Transform (DWT) and Discrete Cosine Transform [5, 6]. That is DCT based on mode 4 Stegnography [8], pseudo code algorithm and compression [6, 7].

The importance of Stegnography increases day by day, so the work and research is also increase in this field. There is lots of research work related audio Stegnography going on by various institutes and individuals. Some papers about dual Stegnography are also proposed. That is using cryptography for providing additional security. All the authors tried to get high capacity and high security.

In kaliappan gopalan proposed a steganalysis in audio file with an encryption key for the embedded secret audio file [9]. In M Asad, J Gilani and A Khalid proposed a audio steganography with an encrypted audio file using advanced Encryption Stardard(AES) [10]. In Mazadak Zaman et. al proposed a genetic algorithm for the embedding secret audio files for achieving higher robustness and capacity [11]. In kaliappan gopalan embed the information of discrete message in spectral domain of a cover audio of image file [12]. In K.B.Raja et. al. proposed a work on image steganography where a LSB embedding is used and then DCT is performed followed by a compression technique to provide high security in the hidden data [13]. In Hossein Malekmohamadi and Shakrokh Ghaemmaghami proposed an enhancement in image steganalysis of LSB matching by reducing the complexity using gober filter coefficients [14]. In R Balagi and G Naveen extended their work towards video steganography by embedding the secret information in some particular frames [15]. In Andrew D. Ker derived a mathematical analysis for the steganalysis in last two LSB bits [16]. S. Khan, M. Haroon Yousaf and M.Jamal Akram proposed an algorithm for Implementation of variable Least Significant Bit steganography [3]. A very related work in DCT domain has recently been published by Sahib Khan et. al using image as cover file [17]

The main task of this paper is to hide data in various number of least significant bits of DCT coefficients' of an audio cover file and analyze the effect of each combination in terms of SNR, PSNR, MSE and data hiding capacity.

is a technique of hidden and secrete writing, the information are hidden in cover media (text, audio, image, video) in both spatial (LSB, VLSB) [1, 2, 3] and transform (DCT, DWT) domain [1]. In spatial domain LSB and VLSB [3, 4] are the most fashionable methods of Stegnography [5]. In transform domain Stegnography has been implemented using Discrete Wavelet Transform (DWT) [6] and Discrete Cosine Transform (DCT) e.g. adaptive DCT based mode 4 Stegnography [8], pseudo-code algorithm [6] and compression [7].

The importance of steganography is increased day by day, and a lot of work is done to enhance this field. kaliappan gopalan proposed an audio steganography algorithm with an encription key for the embedded secret audio file [8]. Mazdak Zamani, Hamed Taherdoost, Azizah A.Manaf, Rabiah B. Ahmad, and Akram M. Zeki work on higher LSB layer of audio file to increased its robustness [9]. Mohammad Pooyan, Ahmad Delforouzi use lifting wavelet transform and calculate the hearing threshold, and according to the threshold data bits are embedded in the least significant bits (LSB) of lifting coefficients [10]. Dimitriy E.Skopin, Ibrahim M.M. El-Emary, Rashad J.Rasras, Ruba S.Diab proposed an algorithm in audio steganography for hiding human speech signal using two methods spectrum shift and spectrum spreading [11]. Masahiro Wakivama, Yasunobu Hidaka, Koichi Nozaki work on wave file as an audio data, and proposed two kinds of new methods of extended low bits coding [12]. Haider Ismael Shahadi, Razali Jidin proposed high capacity audio steganography algorithm based on the wavelet packet transform with adaptive hiding in least significant bits(LSB) [13]. Anupam Kumar Bairagi, Saikat Mondal, Amit Kumar Mondal proposed a method, the message bits are embedded into deeper layer in such a way to increase its robustness [14].

Audio Stegnography is used to hide secret information in audio cover file the secret message is embedded by slightly altering the binary sequence of an audio file. Existing audio Stegnography software can embed message in WAV, AU and even MP3 sound files, in both temporal domain and transform domain. In transform domain Stegnography has been implemented using DWT and DCT etc.

In all previously implemented techniques a specific region/coefficients of the DCT are targeted and data/information are hidden in the least significant bits of specific DCT coefficients. This paper specifically deals with LSB Stegnography using DCT. The main aim of this paper is to find and analyze the effect and contribution of each bit position on SNR and PSNR of Stego image in DCT domain and also to make a comparison with the effect and contribution of each bit position on SNR and PSNR of Stego image in spatial domain.

2. Analysis Parameters

To analyze the effect of different number of least significant bits in DCT coefficients of an audio cover file the SNR, PSNR and MSE are calculated for each combination of least significant bits and the data hiding capacity for each combination is also calculated.

2.1. Hiding Capacity

The information hiding capacity for each combination of least significant bits used is calculated using the expression given.

$$C = \frac{\sum_{i=1}^{N} (Cf_i \times Bi)}{N \times 8} \times 100$$

Where
N: Size of Cover file
Bi: The number of bits hidden in a Coefficient
Cfi: The ith Coefficient

2.2. MSE, SNR and PSNR

The quality of Stego Audio file is analysed quantitatively by calculating mean square error (MSE), signal to noise ratio (SNR) and peak signal to noise ratio (PSNR). The MSE, SNR and PSNR are calculated using expressions given below [18, 19, 20].

$$MSE = \frac{1}{R*C} \sum_{i=1}^{R} \sum_{j=1}^{C} \left[Cov(i,j) - Stego(i,j)) \right]^2$$

$$SNR = 10 * \log_{10} \left[\frac{\sum_{i=1}^{R} \sum_{j=1}^{C} \left[Cov(i,j) \right]^2}{\sum_{i=1}^{R} \sum_{j=1}^{C} \left[Cov(i,j) - Stego(I,j) \right]^2} \right]$$

$$PSNR = 10 * \log_{10} \left[\frac{2^{16} - 1}{MSE} \right]$$

3. Implementation

Hiding data in the least significant bits is a common practice in both spatial domain and transform domain. This work presented in this paper analyze the effect of various number of least significant bits substituted in the DCT coefficients of an audio file. An audio message file is hidden in the least significant bits of the DCT coefficients of cover audio file. The message and cover file are read at the sampling rate of 44100 samples/s and 351800 samples are captured almost equal to 3seconds play time in Matlab. After reading/recording the cover file discrete cosine transform (DCT) is applied on the cover audio file resulting in a group of DCT coefficients. There is a problem of negative values occurring in Matlab and the DCT coefficients are scaled to avoid the negative values and make all coefficients positive. The coefficients are round off to fix the fraction part, by multiplying the DCT coefficient with a suitable number, without any loss. For example after DCT we get a value 0.3528 then we multiply it with 10^4 and get a whole number 3528. By direct rounding off diffidently some will be lost which avoided by the procedure adopted. Then information is hidden in the specific least significant bits. The whole process is explained in the block diagram in figure 1.

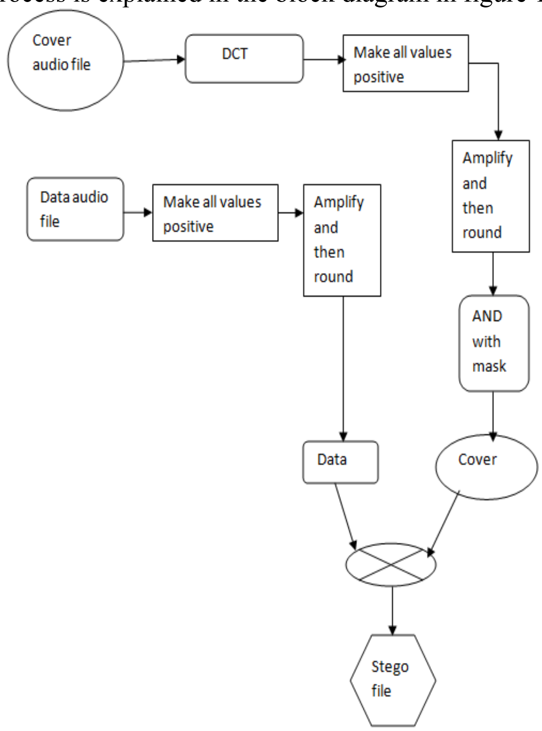

Figure.1: Block diagram of Audio Stegnography in DCT

To make the analysis for various numbers of least significant bits, data is hidden in 1LSB, 2LSBs, 3LSBs, and 4LSBs and so on. For each combination of least significant bits SNR, PSNR, MSE and hiding capacity are calculated.

4. Experimental Results

To analyze the effect of various numbers of least significant bits on SNR, PSNR, MSE and hiding capacity, different numbers of least significant bits of the DCT coefficients of audio file are modified according to the message/information. For each combination of least significant bits the quality measuring parameters and hiding capacity is calculated. It can be clearly observed from the experimental results that hiding capacity significantly increases with the increase in number of least significant bits to substituted in cover file as shown in table 1 while the SNR, PSNR and MSE doesn't changes significantly with the increase in number of bits this trend is quite opposite than that of using image as cover. The values of SNR, PSNR and MSE are also given in table 1.

The time elapsed is also calculated for each combination of least significant bits and is given in table 1. For comparison the SNR, PSNR, MSE, Hiding capacity and estimated time (elapsed time) for each combination of LSBs are shown graphically in figure 2, figure 3, figure 4, figure 5 and figure 6 respectively.

Table1. MSE, PSNR, SNR, Capacity and Processing Time vs LSBs

No of LSBs	SNR (db)	PSNR (db)	MSE (db)	Elapsed time in sec	Capacity in %
1LSB	32.0691	83.7869	71.8334	33.880674	5.8824
2LSBs	32.0690	83.7870	71.8320	35.138149	11.7647
3LSBs	32.0687	83.7872	71.8280	34.358654	17.6471
4LSBs	32.0684	83.7875	71.8228	34.249364	23.5294
5LSBs	32.0678	83.7881	71.8125	34.908435	29.4118
6LSBs	32.0666	83.7894	71.7920	34.769906	35.2941
7LSBs	32.0641	83.7918	71.7511	35.124846	41.1765
8LSBs	32.0591	83.7968	71.6688	35.267543	47.0588

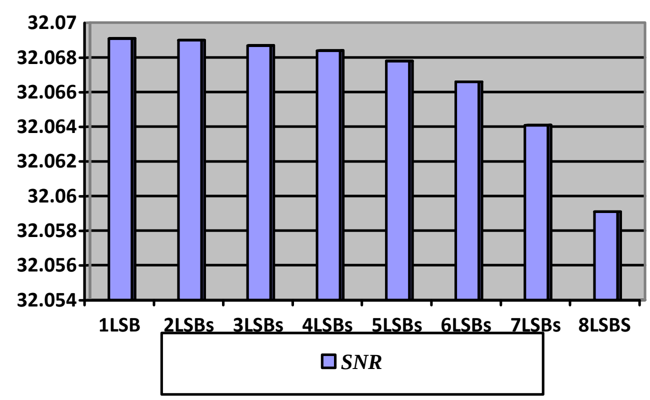

Figure 2: SNR vs. No. of Least Significant Bits

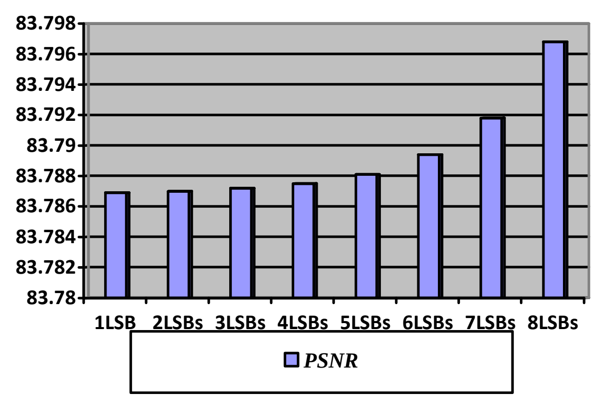

Figure 3: PSNR vs. No. of Least Significant Bits

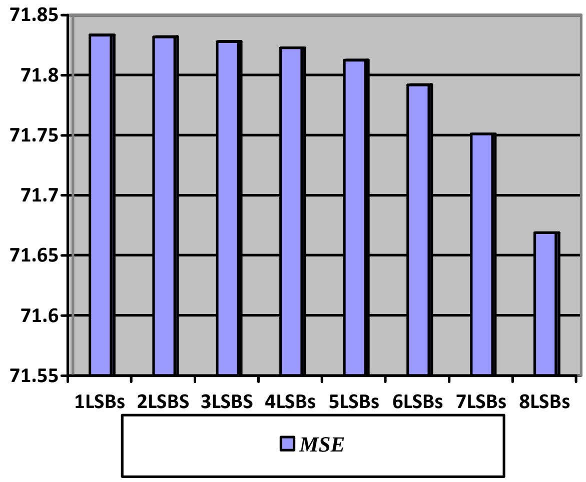

Figure 4: MSE vs. No. of Least Significant Bits

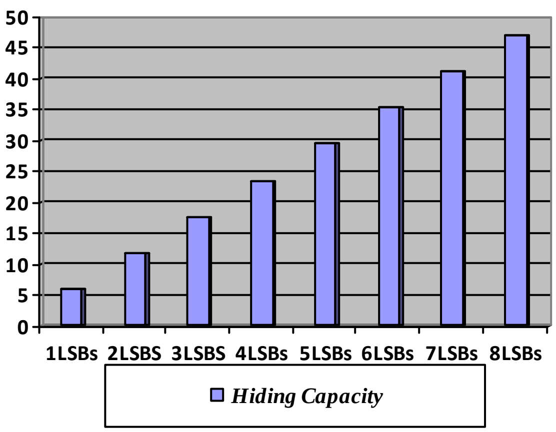

Figure 5: Hiding Capacity vs. No. of Least Significant Bits

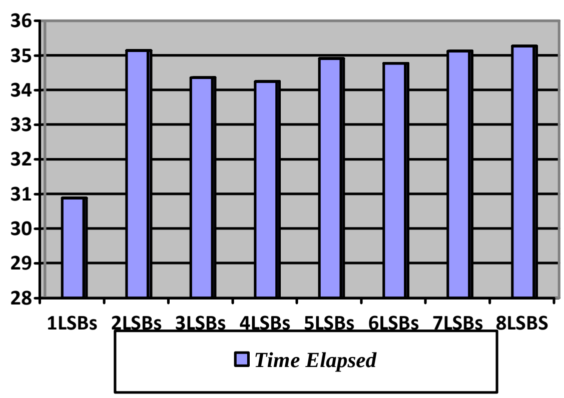

Figure 6: Time Elapsed vs. No. of Least Significant Bits

5. Conclusion

Hiding data in different number of LSBs of DCT coefficients of an audio cover file show a very significant distortion in the cover file for less hiding capacity while almost the same distortion is created for large data hiding capacity of 47 %. The results of SNR, PSNR and MSE show that Audio Stegnography in DCT domain is very suitable for large data hiding instead of less data hiding

References

[1]. S. Dumitrescu, W.X.Wu and N. Memon, "On steganalysis of random LSB embedding in continuous-tone images", Proc. International Conference on Image Processing, Rochester 2002, NY, pp. 641-644.

[2]. S.K. Moon and R.S. Kawitkar," Data Security using Data Hiding", International Conference on Computational Intelligence and Multimedia Applications 2007, pp.247-251.

[3]. S. Khan, M. Haroon Yousaf and M. Jamal Akram, " Implementation of Variable Least Significant Bits Stegnography using Decreasing Distance Decreasing Bits Algorithm", IJCSI Volume 8, Issue 6, November 2011.

[4]. Sahib Khan and Mohammad Haroon Yousaf, "Implementation of VLSB Stegnography Using Modular Distance Technique", Innovations and Advances in Computer, Information, Systems Sciences, and Engineering Lecture Notes in Electrical Engineering Volume 152, 2013, pp 511-525.

[5]. Neeta Deshpande, Kamalapur Sneha, Daisy Jacobs, ―Implementation of LSB Steganography and Its Evaluation for various Bits‖ Digital Information Management, 2006 1st International Conference on. 06/01/2007; DOI: 10.1109/ICDIM.2007.369349

[6]. Sahib Khan and M. Haroon Yousaf, "Variable Least Significant Bits Stegnography". (Accepted for publication in IJCSI Volume 8, Issue 5, September 2011.)

[7]. K.B. Raja, C.R. Chowdary, Venugopal K R, L.M.Patnaik, "a secure image Stegnography using LSB, DCT and compression technique on raw image" 0-7803-9588-3/05/$20.00 ©2005 IEEE

[8]. Muhammad Asad, Junaid Gilani, Adan Khalid, " An Enhanced Significant Bit Modification Technique for Audio Steganography", 2011 International Conference on Computer Networks and Information Technology(ICCNIT), pages 143-147

[9]. Gopalan., "Audio stegangraphy using bit modification", 2003 IEEE international conference on Acoustic, speech and signal processing page(s):II -421 -4 vol.2.

[10]. Muhammad Asad, Junaid Gilani, Adanan Khalid "An Enhanced Significant Bit Modification Technique for Audio Steganography", 2011 international conference on computer Networks and Information Technology (ICCNIT), pages 143-147

[11]. Zamani M., Manaf, A, Ahmad, R.B Jaryani, F., Taherdoost H., Zeki, AM., "A secure audio steganography approach",

Internation Conference for internet Technology and Secured Transactions 2009, page(s):1-6.

[12]. Kaliappan Gopalan, “A Unified Audio and image Steganography by Spectrum Modification”, International Conference on Industrial Technology, 2009, page(s):1-5

[13]. K B Raja , Chowdary C R, Venugopal K R, Patnaik L M “A Secure Image Steganography using LSB DCT and compression Techniques on Raw Images” 2005 IEEE International conference on session B-image signal processing.

[14]. Hossein Malekmohamadi and Shahrokh Ghaemmaghami Reduced Complexity Enhancement Of Steganalysis of LSB-matching Image Steganography” 2009 IEEE/ACS International conference on computer system and applications.

[15]. R Balagi, Naveen G”Secure Data Transmission Using Video Steganography”, 2011 IEEE International conference on electro/information technology (EIT).

[16]. Andrew D.Ker,”Steganalysis of Embedding in Two Least-Significant bits” 2007 IEEE transactions on information forensics and security, vol.2 no.1, march 2007.

[17]. Dmitriy E.Skopin, Ibrahim M. M. EL-Emary, Rashad J.Rasras, Ruba S.Diab, “Advanced Algorithm in Audio Steganography for Human Speech Signal”.

[18]. http://www.mathworks.com

[19]. R.C. Gonzalez and R.E. Woods, 2008. Digital Image Processing. Third Edition, Prentice Hall2008. ISBN: 013168728.

[20]. Sahib Khan, M. Nawaz Khan and Somia Iqbal, “Bit Position based Qualitative and Quantitative Analysis of DCT and Spatial Domain Stegnography”, IJCSI Volume 10, Issue 3, May 2013

Engr. Sahib Khan got M.Sc. in Telecommunication Engineering from University of Engineering and Technology, Taxila in the year 2012 and B.Sc. in Telecommunication Engineering from University of Engineering and Technology, Peshawar in the year 2008. He currently holds the position of Lecturer in the Department of Electrical Engineering at University of Engineering and Technology, Peshawar. His research interests include Image and Signals Processing, Information Security and Antenna designing. He, along with his students, is developing and implementing Stegnographic techniques and algorithms, esp. Image and Audio Stegnography, in Spatial and Transform domains.