Optimization of Steganography on Audio Wave by Embedding the Minimum and Maximum Message in Various Layers and Spy Analysis

Sumit Kumar Moudgil[1] and **Dr. Amit Kumar Goel**[2]
Department of ECE/CSE, FET, Shree Guru Gobind Singh Tricentary University, Gurgaon 122505 Haryana, India
[1]sumitkumarmoudgil@gmail.com, [2]hodcse@sgtengineeringcollege.org

Abstract - **Steganography is a sub-discipline of information hiding that focuses on concealing the existence of messages. It is the study of techniques for hiding the existence of a secondary message in the presence of a primary message. Here we embed minimum and maximum message into the various layers of audio wave. Digital audio is stored on a computer as a sequence of 0's and 1's with the right tools, it is possible to change the individual bits that makeup a digital audio file. Such precise control allows changes to be made to the binary sequence that are not discernible to the human ear. In a computer-based audio steganography system, secret messages are embedded by slightly altering the binary sequence of a sound file. We propose complete steganography on wave audio files using four stages of genetic algorithm – Encryption, Modulation, Decryption and Demodulation. We can hide any text within the layer of data structure of audio wave files.**

Keywords: Steganography, Spy Analysis, Audio Wave

I. INTRODUCTION

THE steganography on Audio wave files were successfully implemented. After the implementation, Spy Analysis was done to test the algorithm on various parameters already introduced in Genetics based algorithm like Robustness, Capacity and Clarity. A GUI was created for easy interaction with the user. Spy Analyses is the step-by-step method coded in Matlab to break the security loop holes in extreme tests to see the clarity, robustness and capacity of the encryption and encoding used in steganography. Spy Analyses includes these methods used in our model of study – SNR ratios testing, Time Domain Analyses, Frequency Domain Analyses, Spectogram Analyses, Transformation Analyses etc. Message added in steganography was of maximum length possible. Testing using Spy Analyses was done using clear, robust, genetic and high capacity encoding – Inverter Method of encoding that negates the message bits embedded in wav file and provides higher capacity but low robustness than spread spectrum methods.

II. SIGNAL-TO-NOISE RATIO TEST

During SNR Ratio testing, we calculated the SNR ratios of audio wave files before and after embedding. The code for this test and all the tests, includes the genetics based more robust algorithms covering capacity and robustness at high levels. Code for SNR ratio calculation is already included in audio stegano.m file which contains the algorithms for Encryption and Decryption along with GUI for performing steganography.

TABLE 1- SIGNAL-TO-NOISE RATIO FOR MESSAGE EMBEDDING

Embedding Layer	SNR (Min. embedding)	SNR (Max. embedding)
FirstLayer	122.33	114.67
SecondLayer	122.33	114.68
ThirdLayer	122.33	114.69
FourthLayer	122.33	114.70
Fifth Layer	122.33	114.71

It can be observed from the table that this algorithm does not show up significant changes in the audio signal under the spy analyses test. Embedding is good at layer of encryption. Alteration: Message bits substitute with the target bits of samples.

To find out the values of sample we use the formula 2^n

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
0	0	1	0	1	1	1	1

0+0+32+0+8+4+2+1 = 47

Modification: It decreases the amount of error and improves the transparency.

Example of adjusting for expected intelligent algorithm
Sample bits are: 00101111 = 47

Bit Position	8	7	6	5	4	3	2	1
Values	0	0	1	0	1	1	1	1

Target bit position is 5, and message bit is 1
Without adjusting: 00111111 = 63 (difference is 16)

After adjusting: 00110000 = 48 (difference will be 1 for 1 bit embedding)

Sample bits are: 00100111 = 39

Bit Position	8	7	6	5	4	3	2	1
Values	0	0	1	0	0	1	1	1

Target bit positions are 4&5, and message bits are 11 without adjusting: 00111111 = 63 (difference is 24) After adjusting: 00011111 = 31 (difference will be 8 for 2 bits embedding)

Verification: This stage is quality controller. Check again the difference

Without adjusting = 63
-Sample bits = - 47, Difference is 16

We design algo such that this difference will be minimized
Noise will be minimum , noise increases if we change the bits

From left to right for example

1. If LSB bit changes, difference will be minimum.
2. If MSB bit changes, difference will be maximum.

Reconstruction

This is the last step for new audio file (stego file) creation. This is done sample by sample.

Time Domain, Frequency Domain and Power Spectrum Analyses : Amplitude and Frequency Analyses (Discrete Fourier Transforms, Power Plots) for embedded layer. This plot gives us any change in Amplitude or Frequency part of the wav audio. The plots of Time-Domain, Frequency Domain and Power Spectral Densities of the Base Wav Signal which was used as a base file on which embedding was done *i.e.* 'LC_House_Beat_123_1.wav'. We can plot this by running 'plots.m' file script. We can easily zoom the plots in Matlab up to any resolution of sample point.

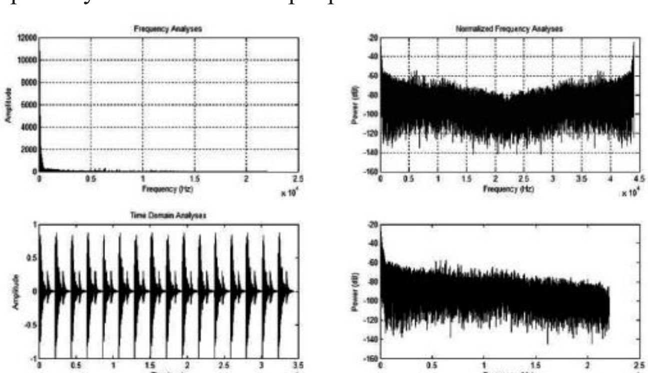

Figure 3. Original Wav Spectrum and Time Domain signal analyses.

First plot is the Amplitude vs. Frequency plot, right to it is the Power Spectrum, third is the Amplitude vs. Time Analyses and fourth one is Single Side Frequencies' Power Spectrum which does not show half repeated alias frequencies. Note the amplitude pattern (3rd Plot) which shows the beat wav pattern. Modifying the beat pattern in frequency domain has also led us to create new types of music beats ex: Risset Beats, which is not possible through modern instruments. Now, we will see the embedded files' spectrums one by one and can easily infer from it that all are very co-related thus we can predict that our algorithm is not only robust in detection but is also of high capacity.

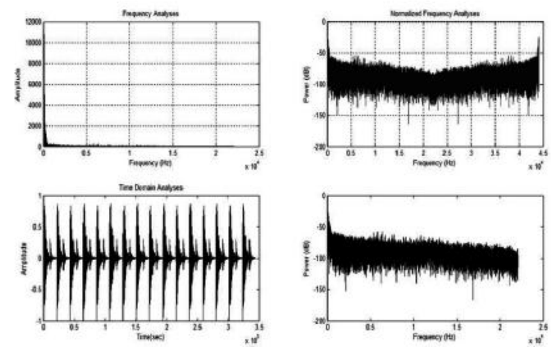

Figure 4. Layer 2 Max EmbeddedAudio Wav signal analyses.

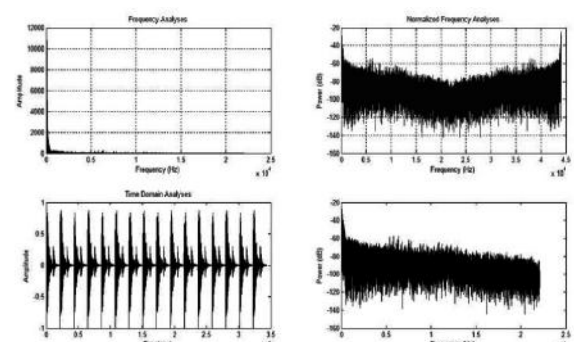

Figure 5. Layer 2 Min EmbeddedAudio Wav signal analyses.

Spectrogram Analyses: Now we will see the spectrum analyses of audio wavfiles on Time vs. Frequency vs. Amplitude response of the signals. Modulation spectrum analysis is emerging as a novel sound representation which has found applications in both ASR as well as most recently in audio coding.We will see spectrogram of original wav file and then *difference* spectrum analyses between (original and max embedding wav) and (original and min embedding wav). Original Signal Wav file – 'LC_House_Beat_123_1.wav' and after embedding it is named as 'lsb1_max.wav' and 'lsb1_min.wav'. We will first plot the original Wav spectrum and then difference of 3D spectrums.

Code for all spectrograms is given in two MATLAB script files –
'spectogram.m'and'DifferenceSpectogram.m'

A. Original Wav:

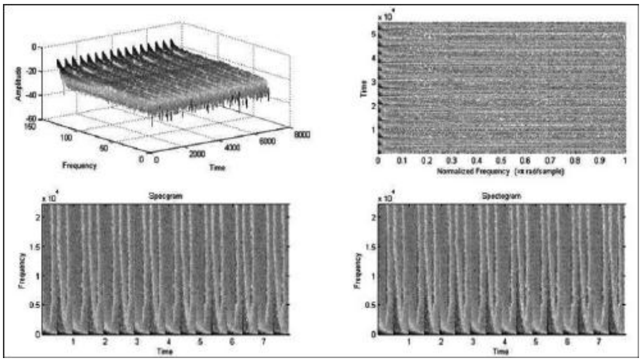

Figure 6. Original Spectrograms of Wav file A.

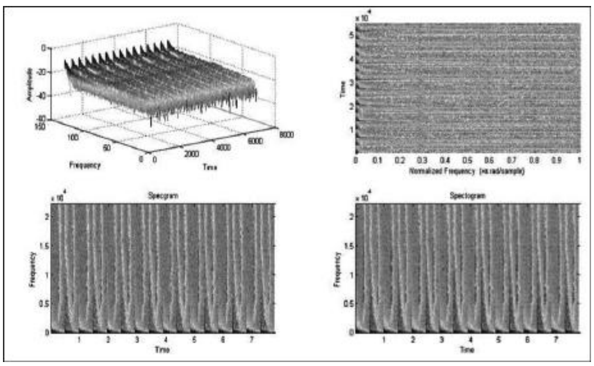

Figure 7. Spectrogram of layer 2 max embedded Wav file a1.

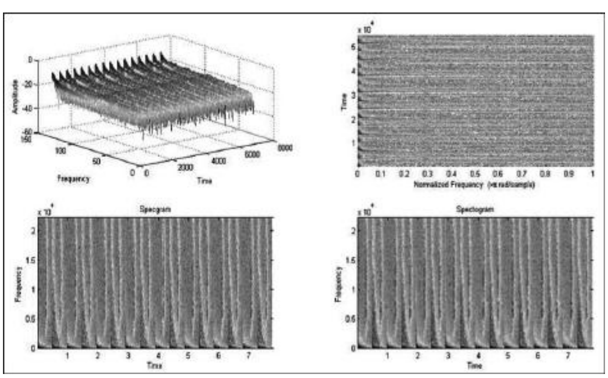

Figure 8. Spectrogram of layer 2 min embedded Wav file b1.

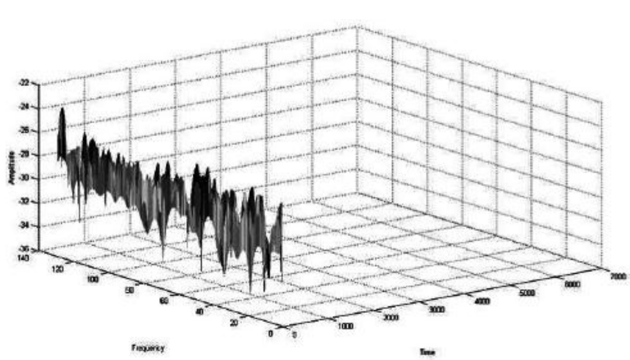

Figure 9. Difference Spectra of Original and Layer 2 Max Embedded Wav (A-a1).

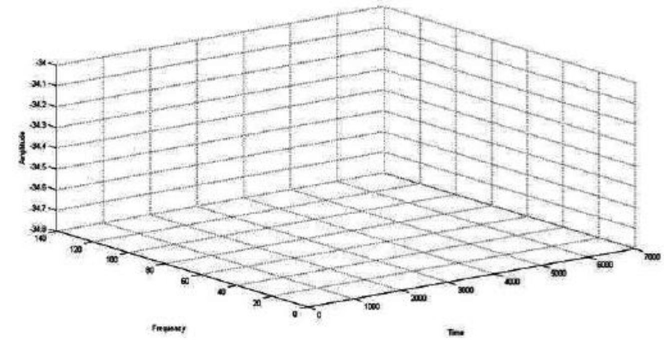

Figure 10. Difference Spectra of Original and Layer 2 Min Embedded Wav (A-b1).

III. DISCUSSION

By modifying different encoding algorithms, we can make even high capacity, highly robust algorithms which can provide even higher security than spread spectrum techniques. Robustness of audio wav can be made even better by the use of more audio spectrographic algorithms. One of the possibilities could be taking a transform of the given signal and choosing the low power coefficients for embedding. This could result to a decrease in the noise in the output signal thereby improving the SNR ratio. We can even make new music wav files by studying the spectrograms of beats and can also produce music that is not possible through the use of instruments *i.e.* Risset Beats etc.

IV. CONCLUSION

It is safer to send an audio wave which was minimum embedded by a secret message in communication. In this paper, a new approach is proposed to resolve two problems of substitution technique of audio steganography. First problem is having low robustness against attacks which try to reveal the hidden message and second one is having low robustness against distortions with high average power. An intelligent algorithm will try to embed the message bits in the deeper layer of samples and alter other bits to decrease the error; and if alteration is not possible for any samples, it will ignore them. Using the proposed genetic algorithm, message bits could be embedded into multiple, vague and deeper layer to achieve higher capacity and robustness.

Spy Analyses is a good algorithm that can make a few nuts go loose and can break the security of even some of the good encryption and encoding algorithms, so we must be sure of the fact that it can only detect that there is a large hidden message in the wav files due to steganography but to break the encryption security we need to break the encoding of communication codes that gives much security, and it cannot detect that there is a small hidden message in the wav file due to steganography that even gives much more security.

Our encoding method depends heavily on identity/key for its security. We have tried to implement different methods to encrypt and encode the steganography in audio wav files, and also gave the spy analyses methods to break through the security hole. Both things can be made tougher and smarter.

V. REFERENCES

[1]. Martín Alvaro, Sapiro Guillermo and SeroussiGadiel, "Is Image Steganography Natural," *IEEE Trans. Image Processing*, Volume 14, Number 12, December, 2005.

[2]. N. Cvejic and T. Seppänen, "Increasing the capacity of LSB based audio steganography", *Proc. 5th IEEE International Workshop on Multimedia Signal Processing,* St. Thomas, VI, December 2002, pp. 336.

[3]. Y.K. Lee and L.H. Chen, "High Capacity Image Steganographic Model," *Proc. IEEE Vision, Image and Signal Processing*, 2000, pp. 288-294.

[4]. Pal S.K., Saxena P. K. and Mutto S.K. "The Future of Audio Steganography", *Proc. Pacific Rim Workshop on Digital Steganography*, Japan, 2002.

[5]. A. Westfeld and A. Pitzmann, "Attacks on Steganographic Systems". *Lecture Notes in Computer Science,* Volume 1768, Springer-Verlag, Berlin, pp. 61-75, 2000.

[6]. Mazdak Zamani, A. Azizah Manaf, B. Rabiah Ahmad, Akram M. Zeki and Shahidan Abdullah, "A Genetic-Algorithm-Based Approach for Audio Steganography", *World Academy of Science, Engineering and Technology* , 2009.

[7]. Fridrich, Jessica *et al*. "Steganalysis of LSB Encoding in Color Images," *Proc IEEE International Conf. Multimedia*. New York: IEEE Press, 2000, pp. 1279–1282.

[8]. I. Aveibas, N. Memon and B. Sankur, "Steganalysis using image quality metrics". *IEEE Trans. Image Processing*, Volume 12, Feb 2003, pp. 221-229.

[9]. M. Alghoniemy and A.H. Tewfik, "Geometric Distortion Correction in Image watermarking", *Proc Electronic Imaging 2000*, Security and Watermarking of Multimedia Contents II, Volume 3971, San Jose, CA, January 2000.

[10]. M. S. Fu, and O. C. Au, "Data Hiding Watermarking for Halftone Images" IEEE Transactions on Image Processing, Vol. 11, No. 4, 2002, pp. 477-484.

[11]. P. Bas, J.M. Chassery and B. Macq, "Geometrically Invariant Watermarking Using Feature Points" *IEEE Trans. Image Processing*, Volume 11, Number 9, September 2002, pp.1014-1028.

[12]. A. Nikolaidis and I. Pitas, "Region-Based Image Watermarking", *IEEE Trans. Image Processing*, Volume 10, Number 11, November 2001, pp. 1726-1740.

[13]. Y.K. Chan and C.C. Chang, "Concealing a Secret Image Using the Breadth First Traversal Linear Quad tree Structure". *Proc. IEEE Third International Symposium on Cooperative Database Systems for Advanced Applications,* pp. 194-199,2001.

[14]. C.Y. Lin *et al.*, "Rotation, Scale and Translation Resilient Watermarking for Images," *IEEE Trans. Image Processing*, Volume 10, Number 5, May 2001.

[15]. S.V Voloshynovskiy *et al,*. "StegoWall: Blind Statistical Detection of Hidden Data," *Proc. Electronic Imaging 2002*, Security and Watermarking of Multimedia Contents IV, San Jose, CA, January 2002, pp. 57-68.

[16]. J.J. Eggers and B. Girod, "Blind Watermarking Applied to Image Authentication," *Proc. IEEE International Conference on Acoustics, Speech and Signal Processing,* (ICASSP), Salt Lake City, May 2001.

Dr. Amit Kumar Goel is Head of Department (Computer Science and Engineering) at SGT University, Gurgaon.He is a distinguished academician with over nineteen years teaching experience in Computer Science and Engineering; published two case studies and more than twenty five research papers; and guided several undergraduate, post-graduate research works. Presently, he is working on one edited book on Soft Computing.

Obtaied BE and M. Tech in Computer Science from Nagpur University and Punjabi University respectively and PhD in "Multiagent System" from Birla Institute of Technology, Mesra. He started his career as System Engineer in R B Aurolite Ltd. in 1996 and then joined as Lecturer in Rukimini Devi Institute of Advnced Studies in 2001, where he worked for 8 years. He was HOD (IT) in GITM, Gurgaon for 6 years and worked as Associate Professor with EIT Faridabad for 2 years. Prior to SGT University, he was Professor with Chandigarh University, Punjab.

Dr. Goel has been a member of Editorial Board of two national journals of repute namely; IIJC and IJAIAT. Dr. Goel has been honoured with "Best Teacher Award" by GITM. He conducted a series of SDPs, FDPs and Conferences.

Sumit Kumar Moudgil is Research Scholar in ECE Department, Faculty of Engineering & Technology at SGT University, Gurugram.

He is a distinguished academician with over Seven years of teaching experience in Electronics and Communication Engineering / CSE; published more than nine research papers; and guided several undergraduate, post-graduate research works.

He is BE, M. Tech in Electronics & Communication from Maharishi Dayanand University, Rohtak and DCR University of Science and Technology, Murthal respectively and Pursuing PhD in "Electronics and Communication Engineering, Steganography on Audio Wave" from SGT University, Gurugram since 2014. He started his career as Lecturer in Management Education and Research Institute, Delhi in 2010. He worked as Assistant Professor and HOD of ECE Department with MERI-CET, Haryana for 3 years. He is a regular Research Scholar in SGT University from 2014 onwards.