



Analysis of Covering Media Used to Hide DSF

Prof. Ziad Alqadi; Prof. Mohammad Abu Zalata

Albalqa Applied University
Faculty of Engineering Technology
Jordan-Amman

DOI: <https://doi.org/10.47760/ijcsmc.2024.v13i01.004>

Abstract:

Digital speech file is an important widely circulated type needed to be protected from being hacked. Data steganography is one of the easiest methods which can be used to protect the speech file. In this paper research the process of using each of the digital image or the digital speech as a covering media will be analyzes. LSB2 and LSB4 will be used for color images, while LSB32, LSB16, LSB8 and LSB4 will be used for a speech covering media, the quality of the obtained stego media will be analyzed to give the user the best choice of selecting the covering media foe digital speech hiding.

Keywords: Speech steganography, covering media, stego media, quality, MSE, PSNR, LSBs set.

Introduction

Digital speech file (DSF) steganography [1-10] is one of the most popular methods used to protect secret speech from being hacked, steganography hides the secret speech into a covering image or DSF without affecting this file and this process is performed by executing hiding and extracting functions. Hiding function as shown in figure 1 processes the secret DSF, and the covering media to produce a stego media, while the extracting function as shown in figure 2 processes the stego to produce the secret data [60-65].

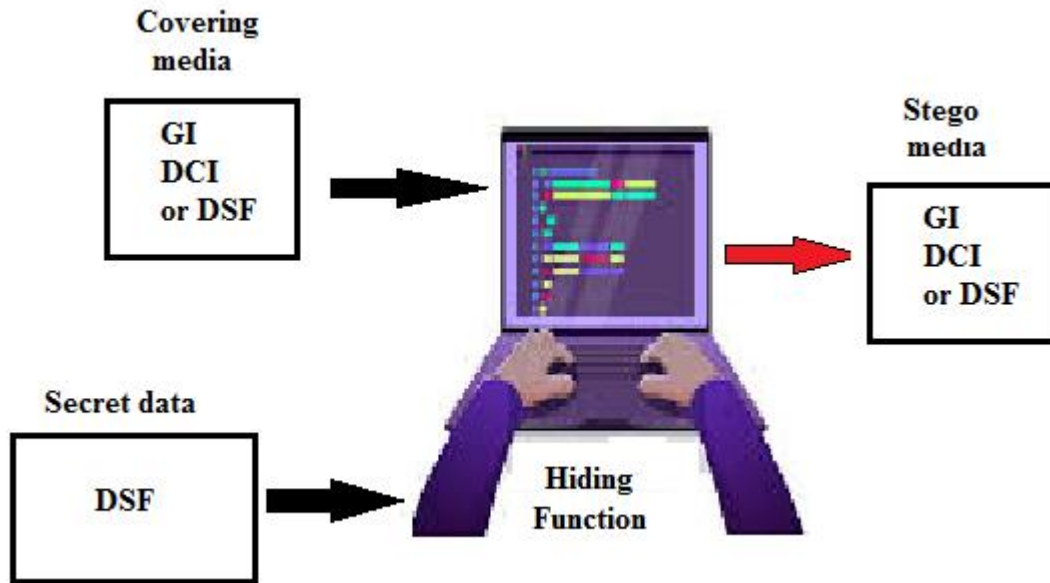


Figure 1: Stego system hiding function

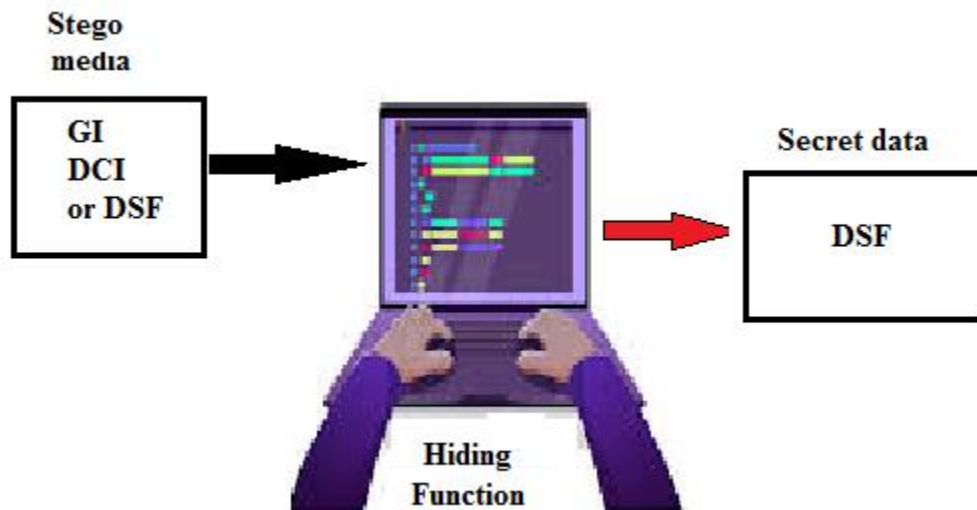


Figure 2: Stego system extracting function

A good stego system will be acceptable if it satisfies the following requirements [54-59]:

- The extracted secret data must be the same as the source data, MSE measured between the source data and the extracted data must equal zero, while PSNR must equal infinity [16-20].
- The stego DSF must have excellent quality, it must be much closer to the covering DSF, the MSE measured between the two files must be very low, while the PSNR must be very high [56-60].
- Increasing the secret data length must not affect the quality of the stego DSF; the value of MSE must be kept low, while the value of PSNR must be kept high [61-66].
- The speed of data hiding must be high, and also the speed of data extracting must be high, the stego system must minimize the hiding and extracting times.
- If possible the stego system must use a PK to protect the hidden data [21-26].
- The stego system must be flexible, it must be capable to process SM, GI, and DCI and changing the data type must not require any changes in the hiding and extracting functions [15-20].

- The stego system must be simple, this can be achieved by simplifying the processes of data hiding and data extracting [50-60].
- The system must be sensitive, to get a correct and not damaged extracted data the extracting function must use the same PK used in the hiding function [11-14].

Many method of data steganography were introduced by many authors, mostly the methods were based on LSB and LSB2 methods [66-69], these methods share a lot of features and some of these features can be considered as disadvantages, these features are [45-54]:

- Moderate speed of data hiding and extracting
- Most of these methods used a color image as a covering media.
- Methods base on LSB method provides a hiding capacity equal the covering media size divided by 8.
- Methods base on LSB2 method provides a hiding capacity equal the covering media size divided by 4.
- Increasing the secret data size length will negatively affect the quality of the stego media, MSE will rapidly increase and PSNR will rapidly decrease when hiding secret data with long size.
- Mostly these methods are not enough secure, they do not use PK.
- The hiding and extracting functions are implemented by executing a complex sequence of logical operations.

Many of the proposed methods for DSF steganography used digital image (gray or color image) as a covering media, and the used LSB1 or LSB2 bits for speech hiding and extracting, and because the speech file has a huge size these methods required a big images to hold the speech, thus the hiding and extracting times will be long. Below we will explain the main features of the most popular covering media used for DSF hiding [20-30]:

1- Gray Image

Gray image (GI) is a set of pixels (bytes) organized in 2D matrix [37-41], this matrix can be easily reshaped to one row matrix, and the row matrix can be easily converted to binary to form the gray image binary matrix (GIBM), this matrix also can be reshaped to any number of columns, GI can also presented by a histogram which shows the number of repetitions of each gray value, figure 3 shows how the gray image can be presented [30-35].

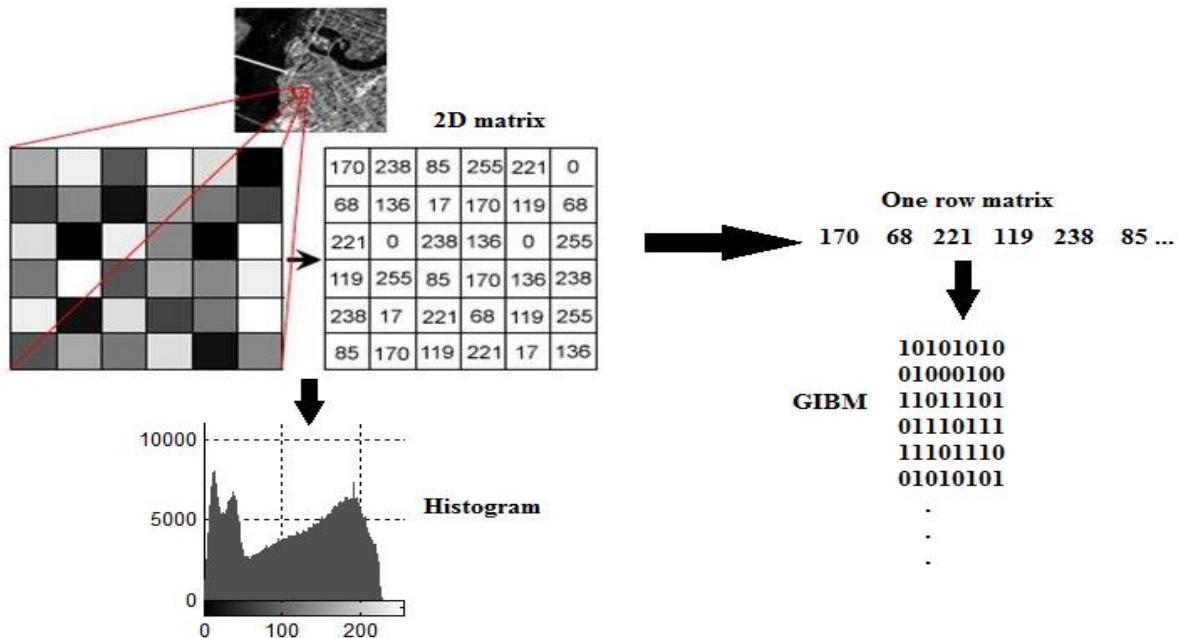


Figure 3: GI presentation

2- Digital Color Image

Digital color image (DCI) [1-10] is a set of pixels (set of 3 bytes: one for the red color value, one for the green and one for the blue) organized in 3D matrix [42-48], this matrix can be easily reshaped to one row matrix, and the row matrix can be easily converted to binary to form the color image binary matrix (CIBM), this matrix also can be

The following example shows how the covering image byte will be changed when changing some LSBs (see table 3)

Covering image byte=123

Binary:

01111011

Table 3: Effect of changing LSBs in an image byte (example)

LSBs	Old LSB value	New LSBs value	New byte value	MSE	PSNR
1	0	1	122	1	96.2437
2	11	00	120	9	74.2714
4	1011	0100	116	49	57.3255

As it is shown in table increasing the number of used LSBs for data hiding will negatively affect the value of the covering byte, this will also affect the quality of stego image. Increasing the number of LSBs used in the covering image to hold a DSF will produce a damaged stego image, and it will be easily discovered that the image is holding a secret data, so 1 or two LSBs can be used when using DCI as a covering media, using more than two LSBs is not recommended when using DCI as a covering media.

The 64-bits representation of the speech sample give us the ability to use more than two LSBs for data hiding without much affecting the value of the speech sample. Here we can use up to 32 LSBs from the speech samples for data hiding, this will increase the capacity hiding and it will equal the covering media size divided by two, each sample of the secret DSF will need two samples from the covering DSF to be hidden, table 4 shows how the covering sample value will change when changing some bits of the sample value.

Sample= 0.1497

Binary:

001111111011100111110010000100101101011101110011000110001111110

Table 4: Effects of replacing LSB bits in the speech sample value

LSBs	Old LSB value	New LSBs value	New byte value	MSE	PSNR
1	0	1	0.1497	7.7037e-034	724.4795
2	10	01	0.1497	7.7037e-034	724.4795
4	1010	0101	0.1497	1.9259e-032	692.2907
8	10011010	01100101	0.1497	2.1640e-030	645.0736
16	0000100010011010	1111011101100101	0.1497	2.8789e-024	504.0640
32	1001111000011011 0000100010011010	0110000111100100 1111011101100101	0.1497	7.8613e-016	309.8116

From tables 3 and 4 we can see that the better covering media to be used to hide the DSF is a covering DSF, and this will give the DSF stego system the following advantages:

- Using any set of LSBs from 1 LSB and up to 32 LSBs will keep the stego media in high quality.
- Increasing the capacity of data hiding, using 32 bits hiding will give us the capacity hiding equal the covering media size divided by two.

To prove the previous facts a DSF with size 64448 samples was selected to be hidden in a covering image 2.2.01.tiff [<https://sipi.usc.edu/database>], with size equal 1024x1024x3=3145728.

LSB2 and LSB4 were selected respectively, and table 5 shows the obtained results:

Table 5: Analysis results using DCI as a covering media

Used LSB	Hiding time (second)	Extracting time (second)	Required number of covering bytes required	MSE	PSNR
LSB2	11.0520	3.1690	2062336<image size	1.7749	103.5392
LSB4	5.7190	2.6260	1031168<image size	14.1862	82.7539

As we can see from table 5, getting a moderate quality of the stego image we have to use LSB2 bits and this will increase both the hiding and extracting times and at the same time will increase the size of the covering bytes. Because of the big size of the DSF to be hidden in the image, a big number of covering bytes will be affected and this negatively affect the quality of the stego image, and looking for the image histogram any one can discover that the image is holding a secret data as shown in figures 7, 8, and 9 produced by the previous implementations:

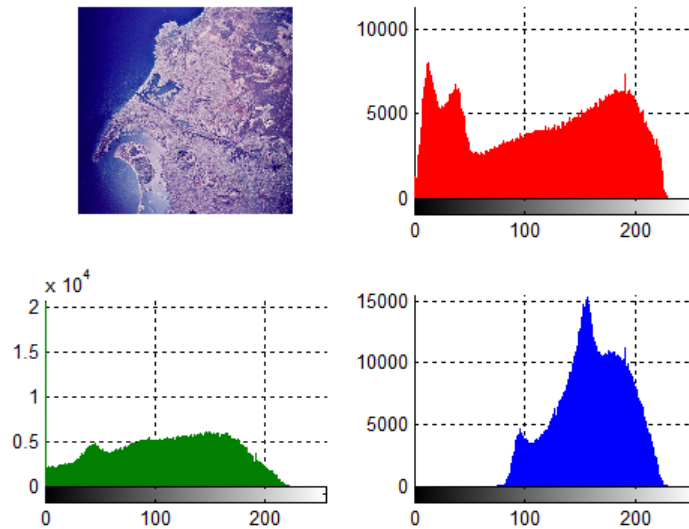


Figure 7: Covering image and histograms

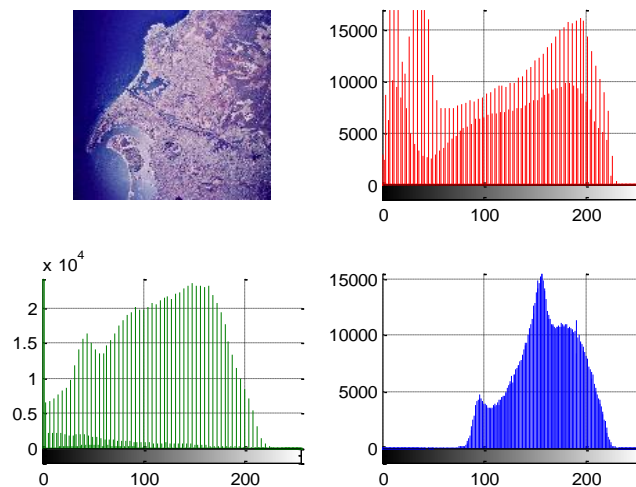


Figure 8: Stego image and histograms using LSB2

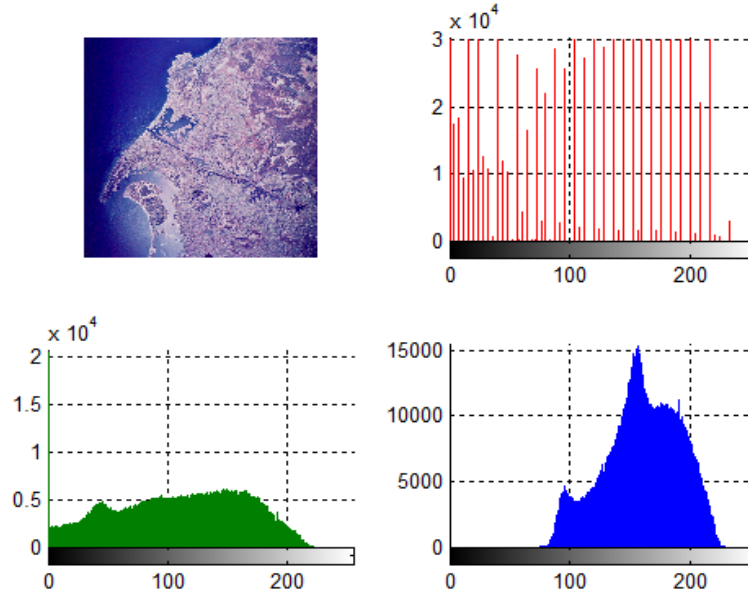


Figure 9: Stego image and histograms using LSB4

The Previous experiment was repeated by using DSF with size equal 1286144 samples as a covering media and table 6 shows the obtained results:

Table 6: Obtained results using DSF as a covering media

Used LSB	Hiding time (second)	Extracting time (second)	Required number of covering bytes required	MSE	PSNR
LSB32	5.9190	3.4690	128896<Covering DSF size	1.1091e-017	364.0827
LSB16	11.3920	4.7900	257792<Covering DSF size	6.7785e-027	576.2391
LSB8	22.6940	7.9580	515584<Covering DSF size	1.6405e-031	682.5301
LSB4	289.0850	16.8450	1031168<Covering DSF size	7.6292e-034	736.2378

From table 6 we can see the following:

- The quality parameters results are better than the quality parameters values when using DCI as a covering media.
- The hiding and extracting times using LSB32 is acceptable.
- Decreasing the number of used LSBs in the DSF will increase the hiding time, extracting time and the number of required covering samples.
- The obtained stego files have an excellent quality (see figure 10 and 11)

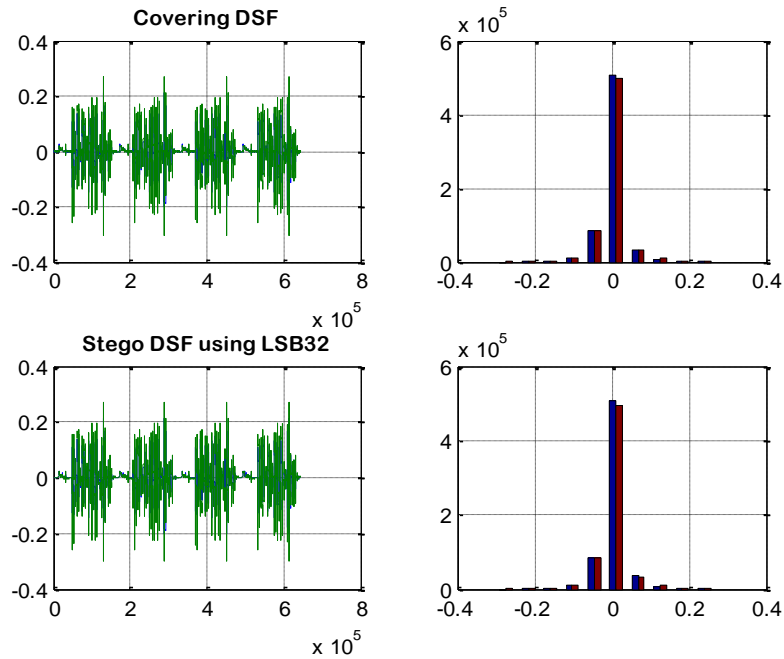


Figure 10 : Stego file using LSB32

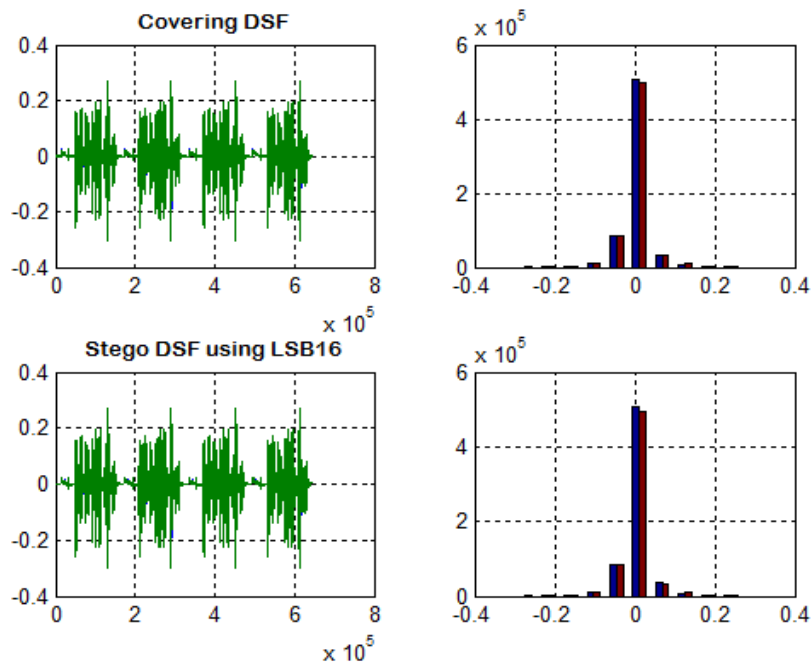


Figure 11 : Stego file using LSB16

Based on the obtained results we can recommend using DSF as covering media to hold another DSF and to use 32 bits from the covering DSF file to hold the samples of the secret DSF.

Conclusion

Two covering Medias to hold a secret digital speech file were analyzed, the first one used a digital color image as a covering media, while the second one used a digital speech file as a covering media. Various number of LSBs were used for data hiding and the results of analysis move us to the following facts:

- It was better to use digital speech file as a covering media/
- Using LSB32 from the covering speech file is the better choice, this choice will decrease the hiding time, the extracting time and will decrease the number of required samples for speech hiding keeping the stego file in excellent quality.

References

- [1]. Prof. Ziad A.A. Alqadi, Prof. Mohammed K. Abu Zalata, Ghazi M. Qaryouti, Comparative Analysis of Color Image Steganography, JCSMC, Vol.5, Issue. 11, November 2016, pg.37–43.
- [2]. M. Jose, “Hiding Image in Image Using LSB Insertion Method with Improved Security and Quality”, International Journal of Science and Research, Vol. 3, No. 9, pp. 2281-2284, 2014.
- [3]. Emam, M. M., Aly, A. A., & Omara, F. A. An Improved Image Steganography Method Based on LSB Technique with Random Pixel Selection. International Journal of Advanced Computer Science & Applications,1(7), pp. 361-366, (2016). <https://doi.org/10.14569/IJACSA.2016.070350>.
- [4]. Mohammed Abuzalata; Ziad Alqadi; Jamil Al-Azzeh; Qazem Jaber, Modified Inverse LSB Method for Highly Secure Message Hiding, IJCSMC, Vol. 8, Issue. 2, February 2019, pg.93 – 103.
- [5]. Rashad J. Rasras, Mutaz Rasmi Abu Sara, Ziad A. AlQadi, Engineering, A Methodology Based on Steganography and Cryptography to Protect Highly Secure Messages Engineering Technology & Applied Science Research, Vol.9 Issue 1, Pages 3681-3684, 2019.
- [6]. Zhou X, Gong W, Fu W, Jin L. 2016An improved method for LSB based color image steganography combined with cryptography. In 2016 IEEE/ACIS 15th Int. Conf. on Computer and Information Science (ICIS), Okayama, Japan, pp. 1–4 . <https://doi.org/10.1109/ICIS.2016.7550955>.
- [7]. Wu D-C, Tsai W-H. A steganographic method for images by pixel value differencing. Pattern Recognition. Lett. 24, 1613–1626. 2003 [https://doi.org/10.1016/S0167-8655\(02\)00402-6](https://doi.org/10.1016/S0167-8655(02)00402-6).
- [8]. Das R, Das I. Secure data transfer in IoT environment: adopting both cryptography and steganography techniques. In Proc. 2nd Int. Conf. on Research in Computational Intelligence and Communication Networks, Kolkata, India, pp. 296–301, 2016. <https://doi.org/10.1109/ICRCICN.2016.7813674>.
- [9]. Rashad J. Rasras, Mutaz Rasmi Abu Sara, Ziad A. AlQadi, Rushdi Abu zneit, Comparative Analysis of LSB, LSB2, PVD Methods of Data Steganography, International Journal of Advanced Trends in Computer Science and Engineering, vol. 8, issue 3, pp.748-754, 2019, <http://www.warse.org/IJATCSE/static/pdf/file/ijatcse64832019.pdf>
- [10].Ayman Al-Rawashdeh, Ziad Al-Qadi, using wave equation to extract digital signal features, Engineering, Technology & Applied Science Research, vol. 8, issue 4, pp. 1356-1359, 2018.
- [11].K Matrouk, A Al-Hasanat, H Alasha'ary, Z. Al-Qadi Al-Shalabi, “Speech fingerprint to identify isolated word person”, World Applied Sciences Journal, Vol. 31, No. 10, pp. 1767-1771, 2014.
- [12].Saleh Khawatreh, Belal Ayyoub, Ashraf Abu-Ein, Ziad Alqadi , A Novel Methodology to Extract Voice Signal Features , International Journal of Computer Applications, Volume 179 – No.9, January 2018.
- [13].Ziad Alqadi, Bilal Zahran, Qazem Jaber, Belal Ayyoub, Jamil Al-Azzeh, Enhancing the Capacity of LSB Method by Introducing LSB2Z Method, International Journal of Computer Science and Mobile Computing, vol. 8, issue 3, pp. 76-90, 2019.
- [14].Ziad A. Alqadi, Majed O. Al-Dwairi, Amjad A. Abu Jazar and Rushdi Abu Zneit, Optimized True-RGB color Image Processing, World Applied Sciences Journal 8 (10): 1175-1182, ISSN 1818-4952, 2010.
- [15].Waheeb, A. and Ziad AlQadi, Gray image reconstruction. Eur. J. Sci. Res., 27: 167-173, 2009.
- [16].A. A. Moustafa, Z. A. Alqadi, “Color Image Reconstruction Using a New R'GI Model”, Journal of Computer Science, Vol.5, No. 4, pp. 250-254, 2009.
- [17].Prof. Ziad A.A. Alqadi, Prof. Mohammed K. Abu Zalata, Ghazi M. Qaryouti, Comparative Analysis of Color Image Steganography, IJCSMC, Vol.5, Issue. 11, November 2016, pg.37–43.
- [18].H. Alasha'ary, K. Matrouk, A. Al-Hasanat, Z. A alqadi, H. Al-Shalabi (2013), Improving Matrix Multiplication Using Parallel Computing, International Journal on Information Technology (I.RE.I.T.) Vol.1, N. 6 ISSN 2281-2911.

- [19].Bilal Zahran, Ziad Alqadi, Jihad Nader, Ashraf Abu Ein A COMPARISON BETWEEN PARALLEL AND SEGMENTATION METHODS USED FOR IMAGE ENCRYPTION-DECRYPTION, International Journal of Computer Science & Information Technology (IJCSIT) Vol 8, No 5, October 2016.
- [20].Z.A. Alqadi, A. Abu-Jazar (2005), Analysis of Program Methods Used for Optimizing Matrix Multiplication, Journal of Engineering, vol. 15 n. 1, pp. 73-78.
- [21].Jamil Al-Azzeh, Bilal Zahran, Ziad Alqadi, Belal Ayyoub, Muhammed Mesleh: A Novel Based On Image Blocking Method to Encrypt-Decrypt Color JOIV: International Journal on Informatics Visualization, 2019.
- [22].Jamil Al-Azzeh, Bilal Zahran, Ziad Alqadi, Belal Ayyoub and Mazen Abu-Zaher: A Novel Zero-Error Method to Create a Secret Tag for an Image; Journal of Theoretical and Applied Information Technology 15th July 2018.
- [23].Jamil Al Azzeh, Ziad Alqadi Qazem, M. Jabber: Statistical Analysis of Methods Used to Enhanced Color Image Histogram; XX International Scientific and Technical Conference; Russia May 24-26, 2017.
- [24].Jamil Al Azzeh, Hussein Alhatamleh, Ziad A. Alqadi, Mohammad Khalil Abuzalata: Creating a Color Map to be used to Convert a Gray Image to Color Image; International Journal of Computer Applications (0975–8887). Volume 153 – No2, November 2016.
- [25].Khaled Matrouk, Abdullah Al- Hasanat, Haitham Alasha'ary, Ziad Al-Qadi, Hasan Al-Shalabi Analysis of Matrix Ziad Alqadi et al, International Journal of Computer Science and Mobile Computing, Vol.8 Issue.3, March- 2019, pg. 76-90.
- [26].Mohammed Abuzalata; Ziad Alqadi, Jamil Al-Azzeh; Qazem Jaber Modified Inverse LSB Method for Highly Secure Message Hiding: International Journal of Computer Science and Mobile Computing, Vol.8 Issue.2, February- 2019, pg. 93-103.
- [27].Qazem Jaber Rashad J. Rasras, Mohammed Abuzalata, Ziad Alqadi, Jamil Al-Azzeh; Comparative Analysis of Color Image Encryption-Decryption Methods Based on Matrix Manipulation: International Journal of Computer Science and Mobile Computing, Vol.8 Issue.2, 2019/3.
- [28].Jamil Al-Azzeh, Ziad Alqadi, Mohammed Abuzalata; Performance Analysis of Artificial Neural Networks used for Color Image Recognition and Retrieving: International Journal of Computer Science and Mobile Computing, Vol.8 Issue.2, February- 2019.
- [29].Rashad J. Rasras, Mohammed Abuzalata; Ziad Alqadi; Jamil Al-Azzeh; Qazem Jaber, Comparative Analysis of Color Image Encryption-Decryption Methods Based on Matrix Manipulation International Journal of Computer Science and Mobile Computing, Vol.8 Issue.3, March- 2019, pg. 14-26.
- [30].AlQaisi Aws, AlTarawneh Mokhled, A Alqadi Ziad, A Sharadqah Ahmad , Analysis of Color Image Features Extraction using Texture Methods , TELKOMNIKA, vol. 17, issue 3, 2018.
- [31].B. Zahran, J. AL-Azzeh, Z. Al Qadi, M. Al Zoghoul and S. Khawatreh, "A MODIFIED LBP METHOD TO EXTRACT FEATURES FROM COLOR IMAGES", Journal of Theoretical and Applied Information Technology(JATIT), Vol.96. No 10, 2018.
- [32].J. AL-AZZEH, B. ZAHRAN, Z. ALQADI, B. AYYOUB, M. ABU-ZAHER, "A novel Zero-error Method to Create a Secret Tag for an Image", Journal of Theoretical and Applied Information Technology(JATIT), Vol.96. No 13, 2018.pp: 4081-4091.
- [33].J. AL-AZZEH, B. ZAHRAN, Z. ALQADI," Salt and Pepper Noise: Effects and Removal", International Journal on Informatics Visualization, Vol.2. No 4, 2018.pp: 252-256.
- [34].Jihad Nader, Ziad Alqadi, Bilal Zahran, "Analysis of Color Image Filtering Methods", International Journal of Computer Applications (IJCA), Volume 174, issue 8, 2017, pp:12-17.
- [35].Ziad Alqadi, Bilal Zahran, Jihad Nader, " Estimation and Tuning of FIR Low pass Digital Filter Parameters", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 7, Issue 2, 2017, pp:18-23.
- [36].Khaled Aldebei, Mua'ad M. Abu-Faraj, Ziad A. Alqadi, Comparative Analysis of Fingerprint Features Extraction Methods, Journal of Hunan University Natural Sciences, vol. 48, issue 12, pp. 177-182, 2022.
- [37].Dr. Mohamad Barakat Prof. Ziad Alqadi, Highly Secure Method for Secret Data Transmission, International Journal of Scientific Engineering and Science, vol. 6, issue 1, pp. 49-55, 2022.
- [38].Ziad A. Alqadi Mua'ad M. Abu-Faraj, Rounds Reduction and Blocks Controlling to Enhance the Performance of Standard Method of Data Cryptography, International Journal of Computer Science and Network Security, vol. 21, issue 12, pp. 648-656, 2021.
- [39].Ziad Alqadi Mua'ad Abu-Faraj , Khaled Aldebei, DEEP MACHINE LEARNING TO ENHANCE ANN PERFORMANCE: FINGERPRINT CLASSIFIER CASE STUDY, JOURNAL OF SOUTHWEST JIAOTONG UNIVERSITY, vol. 56, issue 6, pp. 686-694, 2021.

- [40].Ziad A. Alqadi Mua'ad M. Abu-Faraj, Improving the Efficiency and Scalability of Standard Methods for Data Cryptography, International Journal of Computer Science and Network Security, vol. 21, issue 12, pp.451-458, 2021
- [41].Mua'ad M. Abu-Faraj Prof. Ziad Alqadi, Using Highly Secure Data Encryption Method for Text File Cryptography, International Journal of Computer Science and Network Security, vol. 20, issue 11, pp. 53-60, 2021.
- [42].AlQaisi Aws, AlTarawneh Mokhled, A Alqadi Ziad, A Sharadqah Ahmad, Analysis of Color Image Features Extraction using Texture Methods, TELKOMNIKA, vol. 17, issue 3, 2018.
- [43].Ziad A AlQadi Amjad Y Hindi, O Dwairi Majed, PROCEDURES FOR SPEECH RECOGNITION USING LPC AND ANN, International Journal of Engineering Technology Research & Management, vol. 4, issue 2, pp. 48-55, 2020.
- [44].Ziad A Alqadi, Mohamad Tariq Barakat, A Case Study to Improve the Quality of Median Filter, International Journal of Computer Science and Mobile Computing, vol. 10, issue 11, pp. 19 – 28, 2021.
- [45].Dr. Hatim Ghazi Zaini Prof. Ziad Alqadi, High Salt and Pepper Noise Ratio Reduction, International Journal of Computer Science and Mobile Computing, vol. 10, issue 9, pp. 88 – 97, 2021.
- [46].Prof. Mohamad K. Abu Zalata, Hussein N. Hatamleh, Prof. Ziad A. Alqadi, Detailed Study of Low Density Salt and Pepper Noise Removal from Digital Color Images, IJCSMC, Vol. 11, Issue. 2, PP. 56 – 67, February 2022.
- [47].M. Abu-Faraj, A. Al-Hyari, K. Aldebei, B. Al-Ahmad, and Z. Alqadi, “Rotation Left Digits to Enhance the Security Level of Message Blocks Cryptography,” IEEE Access, vol. 10, pp. 69388- 69397, 2022, doi:10.1109/ACCESS.2022.3187317.
- [48].M. Abu-Faraj, A. Al-Hyari, and Z. Alqadi, “Experimental Analysis of Methods Used to Solve Linear Regression Models,” CMC-Computers, Materials & Continua, vol. 72, no. 3, pp. 5699-5712, 2022, doi:10.32604/cmc.2022.027364. (Web of Science Indexed, Scopus Indexed).
- [49].M. Abu-Faraj, A. Al-Hyari, and Z. Alqadi, “Complex Matrix Private Key to Enhance the Security Level of Image Cryptography,” Symmetry, vol. 14, Iss. 4, pp. 664-678, 2022, doi:10.3390/sym0664. (Web of Science Indexed, Scopus Indexed)
- [50].M. Abu-Faraj, K. Aldebei, and Z. Alqadi, “Simple, Efficient, Highly Secure, and Multiple Purposed Method on Data Cryptography,” Traitement du Signal, vol. 39, no. 1, pp. 173-178, 2022, doi:10.18280/ts.390117. (Web of Science Indexed, Scopus Indexed)
- [51].M. Abu-Faraj, and Z. Alqadi, “Rounds Reduction and Blocks Controlling to Enhance the Performance of Standard Method of Data Cryptography,” International Journal of Computer Science and Network Security (IJCSNS), vol. 21, no. 12, pp. 648-656, 2021, doi: 10.22937/IJCSNS.2021.21.12.89. (Web of Science Indexed)
- [52].M. Abu-Faraj, and Z. Alqadi, “Improving the Efficiency and Scalability of Standard Methods for Data Cryptography,” International Journal of Computer Science and Network Security (IJCSNS), vol. 21, no.12, pp. 451-458, 2021, doi:10.22937/IJCSNS.2021.21.12.61. (Web of Science Indexed)
- [53].M. Abu-Faraj, and Z. Alqadi, “Using Highly Secure Data Encryption Method for Text File Cryptography,” International Journal of Computer Science and Network Security (IJCSNS), vol. 21, no.12, pp. 53-60, 2021, doi:10.22937/IJCSNS.2021.21.12.8. (Web of Science Indexed)
- [54].M. Abu-Faraj, and M. Zubi, “Analysis and Implementation of Kidney Stones Detection by Applying Segmentation Techniques on Computerized Tomography Scans,” Italian Journal of Pure and Applied Mathematics, iss. 43, pp. 590-602, 2020. (Scopus Indexed)
- [55].Prof. Ziad Alqadi, Bits Substitution to Secure LSB Method of Data Steganography, International Journal of Computer Science and Mobile Computing, vol. 11, issue 8, pp. 9 – 21, 2022.
- [56].Mohammad S. Khrisat Prof. Ziad Alqadi, Enhancing LSB Method Performance Using Secret Message Segmentation, International Journal of Computer Science and Network Security, vol. 22, issue 7, pp. 1-6, 2022.
- [57].Hatim Ghazi Zaini and Ziad A. Alqadi Mohammad S. Khrisat, Adnan Manasreh, COVER IMAGE REARRANGEMENT TO SECURE LSB METHOD OF DATA STEGANOGRAPHY, Journal of Engineering and Applied Sciences, vol. 17, issue 3, pp. 294-302, 2022.
- [58].Mohamad K Abu Zalata, Mohamad T Barakat, Ziad A Alqadi, Carrier Image Rearrangement to Enhance the Security Level of LSB Method of Data Steganography, International Journal of Computer Science and Mobile Computing, vol. 11, issue 1, pp. 182 – 193, 2022.

- [59].Dr. Mohamad barakat Prof. Ziad Alqadi, IMAGE TRANSFORMATION TO INCREASE THE SECURITY LEVEL OF LBS METHOD OF DATA STEGANOGRAPHY, International Journal of Engineering Technology Research & Management, vol. 6, issue 1, pp. 42-53, 2022.
- [60].Naseem Asad, Ismail Shayeb, Qazem Jaber, Belal Ayyoub, Ziad Alqadi, Ahmad Sharadqh, creating a Stable and Fixed Features Array for Digital Color Image, IJCSMC, Vol. 8, Issue. 8, August 2019, pg.50 – 62.
- [61].Majed O. Al-Dwairi, Amjad Y. Hendi, Mohamed S. Soliman, Ziad A.A. Alqadi, A new method for voice signal features creation, International Journal of Electrical and Computer Engineering (IJECE), vol. 9, issue 5, pp. 4092-4098, 2018.
- [62].Akram A. Moustafa and Ziad A. Alqadi, A Practical Approach of Selecting the Edge Detector Parameters to Achieve a Good Edge Map of the Gray Image, Journal of Computer Science 5 (5): 355-362, 2009.
- [63].ZA Alqadi, Musbah Aqel, Ibrahiem MM El Emary, Performance analysis and evaluation of parallel matrix multiplication algorithms, World Applied Sciences Journal, vol. 5, issue 2, pp. 211-214, 2008.
- [64].Ismail Shayeb, Naseem Asad, Ziad Alqadi, Qazem Jaber, Evaluation of speech signal features extraction methods, Journal of Applied Science, Engineering, Technology, and Education is licensed under an Attribution-Non Commercial-Share Alike 4.0 International (CC BY-NC-SA 4.0)
- [65].Dr. Mohammed Abbas Fadhil Al-Husainy, COMPARISON STUDY BETWEEN CLASSIC-LSB, SLSB AND DSLSB IMAGE STEGANOGRAPHY, ICIT 2013 The 6th International Conference on Information Technology.
- [66].Kaur, R. Dhir, & G. Sikka,“A new image steganography based on first component alteration technique”, International Journal of Computer Science and Information Security (IJCSIS), 6, pp.53-56, 2009.<http://arxiv.org/ftp/arxiv/papers/1001/1001.1972.pdf>.
- [67].Alvaro Martin, Guillermo Sapiro, &GadielSeroussi,“Is Steganography Natural”, IEEE Transactions on Image Processing, 14(12), pp.2040-2050, 2005.doi: 10.1109/TIP.2005.859370 .
- [68].Bhattacharyya, A. Roy, P. Roy, & T. Kim, "Receiver compatible data hiding in color image", International Journal of Advanced Science and Technology, 6, pp.15-24, 2009. <http://www.sersc.org/journals/IJAST/vol6/2.pdf> .
- [69].Namer Ali Aletawi; Mansour A. Abu Sameha; Prof. Ziad Alqadi, Modified LSB2 Steganography Method to Secure the Embedded Secret Message, IJCSMC, Vol. 11, Issue. 8, August 2022, pg.22 – 44.