Available Online at www.ijcsmc.com/journal

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X

IMPACT FACTOR: 7.056

IJCSMC, Vol. 11, Issue. 4, April 2022, pg.25 – 35

Secure, Based on Pixel Value Encoding-Decoding Method for Medical Color Image Cryptography

Dr. Ziad Alqadi
Albalqa Applied University, Faculty of Engineering Technology
Department of Electrical Engineering, Jordan-Amman

DOI: https://doi.org/10.47760/ijcsmc.2022.v11i04.005

Abstract: Protecting the medical colored digital image from intruders or from the process of penetration is very important, because the medical digital image may be secret or private, or it may be a carrier of confidential data. In this research paper, we will present a new method for encrypting and decrypting the medical digital image in order to secure the protection process for the medical digital image. The introduced method will use image-private key to apply image cryptography, this key will be kept in secrete and it can be used to encrypt-decrypt any image with any size, The image key can be easily changed when the needs arise to insure the security issues. The proposed method will tested to show that it will provide excellent values for MSE and PSNR to prove that the method will satisfy the requirement of good method of medical image cryptography.

Keywords: MCI**,** Image_key, PK, cryptography, MSE, PSNR, image quality, resizing.

Introduction

Medical colored digital images (MCI) [1-6] are considered one of the most important types of digital data in circulation and used now, as they are included in many vital and important applications, which requires protecting them from the danger of intruders and from any hacking attempts. The importance of protecting the MCI is due to several reasons, the most important of which are[43-47]:

The MCI may be confidential or of a personal nature so that no unauthorized party has the right to see or understand it.
The MCI may be a medium for concealing confidential data that requires protection from the risk of penetration.

Various advanced equipment's are now available through which the MCI can be generated with very high resolution [7-10], which makes the MCI a huge data store that can be employed for multiple purposes.

The MCI [16-19] consists of a huge number of pixels distributed in a three-dimensional array, each dimension is assigned to one of the three colors (red, green, blue), as shown in the figure 1[11-15].

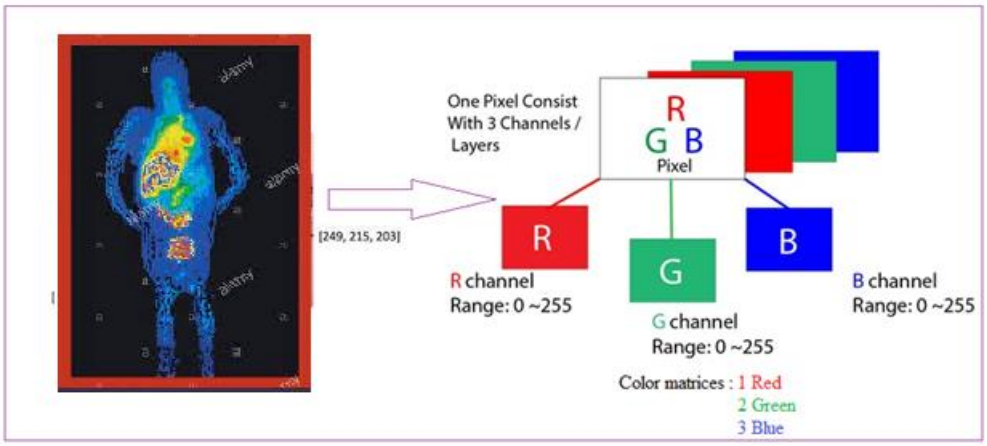

Figure 1: MCI matrices

One of the common methods used to protect the MCI is the data cryptography method [21], which means encrypt the image using private key (PK) to get the encrypted image[23], [24], then decrypt the encrypted image using the same PK to get the decrypted image as shown in figure 2.

There are important requirements that the encryption and decryption method must meet, the most important of which are:

The method must be secure and cannot be hacked. This requirement can be achieved through the use of a PK that is difficult to hack or guess.

The method works to destroy the original MCI by producing an encrypted image that is completely difficult to understand. This requirement can be achieved by employing the PK to implement some secret operations to process the image and produce the encrypted image[48-56].

An image that is completely identical to the original should be returned after performing the decryption process.

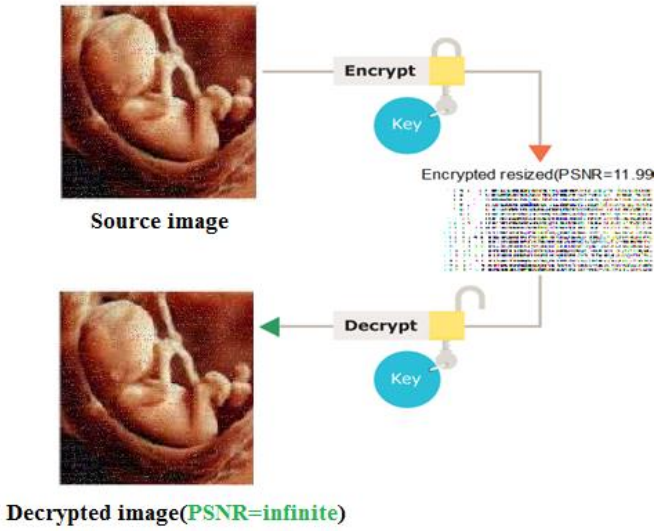

Figure 2: MCI cryptography

The quality of the encrypted-decrypted images can be measured by the quality factors: PSNR (peak signal to noise ratio) and/or MSE (mean square error) between the encrypted and decrypted images and the original image, these factors can be calculated using equations 1 and 2[21].

$$MSE = \frac{1}{mn}\sum_{0}^{m-1}\sum_{0}^{n-1}\|f(i,j) - g(i,j)\|^2 \quad (1)$$

$$PSNR = 20\log_{10}\left(\frac{MAX_f}{\sqrt{MSE}}\right) \quad (2)$$

The second requirement of image cryptography is to achieve a fully distraction of the image after processing the encryption phase, PSNR value between the original and encrypted image must be very low, while the MSE value between the two images must be very high. The third requirement of image cryptography is to achieve a fully recovery of the image after processing the decryption phase, PSNR value between the original and decrypted image must be infinite, while the MSE value between the two images must equal zero.

Related works

Many methods are used for data cryptography [30-34], some of these methods are based on the standards DES (data encryption standard) and AES (advanced encryption standard) [35], these methods are recommended for text data with small sizes, and it is difficult to adopt them for MCI cryptography because of the following reasons:

The size of the image is very large, which makes it difficult to divide it into small fixed-size blocks, and the process of assembling the encrypted blocks is difficult, which leads to an increase in the encryption-decryption time and thus reduces the efficiency of the encryption-decryption process.

The length of the private key is fixed and short, which makes it possible to hack it, and thus negatively affects the security of the image cryptography.

These methods required many operations and rounds to accomplish the process of cryptography which will negatively affect the process efficiency.

Some used methods are base on matrix multiplication [22], [36] by selecting a matrix key to be used in the encryption process and the inverse of this matrix to be used in the decryption process, this will generate a double pixels values which some times leads to some problems when converting double value to integer values (within the range 0 to 255).

Other used methods are based on using XORing operation [37-42]; these methods cannot give good values of MSE and PSNR during the encryption and decryption phases.

Materials and Methods

The proposed method was programmed and implemented using matlab environment. Before describing the proposed method we will briefly explain some basic operations used in the proposed method [25-29].

Private key preparation

This task is required to prepare the image_key to be used as a PK, and it can be implemented applying the steps shown in figure 3:

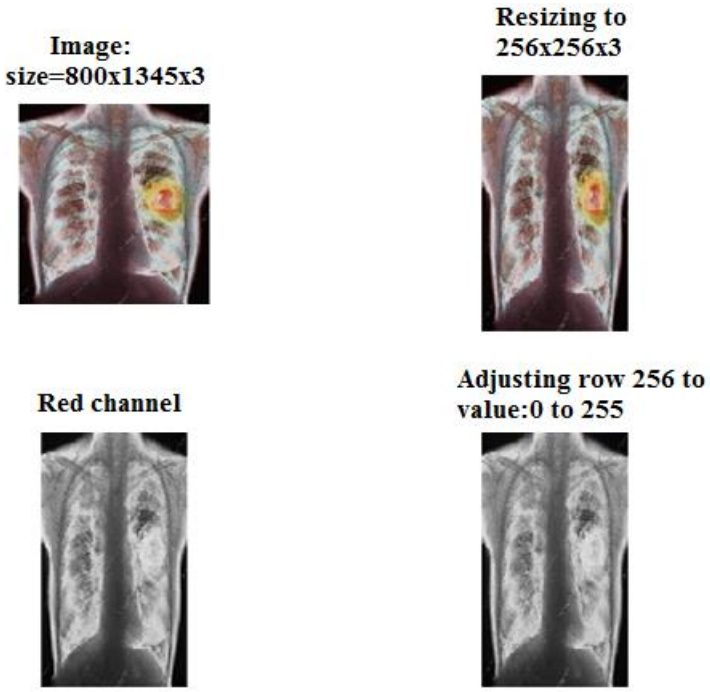

Figure 3: PK preparation

Select a color image to be used as an image_key, this image must be kept in secrete between the sender and receiver, the sender and receiver must agree on the image to be used as a key without performing the messaging process for it, in order to maintain its confidentiality, which makes the process of penetrating it impossible, knowing that it can be changed by another image if the need arises.

The image key must resized to 256 by 256 to keep the codes of the row and column within a range equal the pixel value range, figure 4 shows an example of image resizing.

One channel of the resized color image must be selected.

One row or one column must be changes to the values 0 to 255 to insure that the image key covers all the pixel values range (0 to 255).


```
w =

   188    63   112     5    25   178   207
   100   105    39   135   129    60    30
    79   200   209   124    55    50   250
   223    35   102   100   188   220   125
   159    97   173   121    30   110   134
    61   141    90   212    61    90   230
   154   194    59    64   143   204   100

>> b=imresize(w,[4, 5])

b =

   188   112     5    25   207
    79   209   124    55   250
   159   173   121    30   134
   154    59    64   143   100
```

Figure 4: Image resizing example

Image reshaping: Image matrix can be reshaped from 2D matrix to 1D matrix, or from 1D matrix to 2D matrix, this simple operation can be implemented as shown in the example illustrated in figure 5:

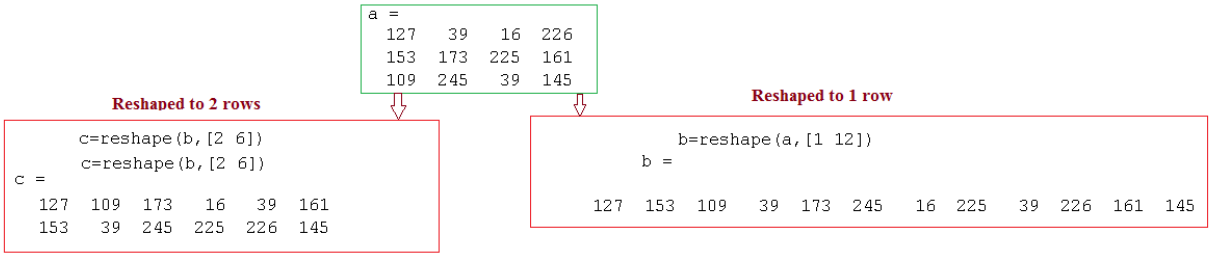

Figure 5: Image reshaping example

Pixel value encoding –decoding

This operation must be executed for each pixel in the image to be encrypted, the pixel value will be replaced by the first row and column numbers of the image key, where the location contents equal the pixel value, figure 6 illustrate an example of applying pixel value encoding:

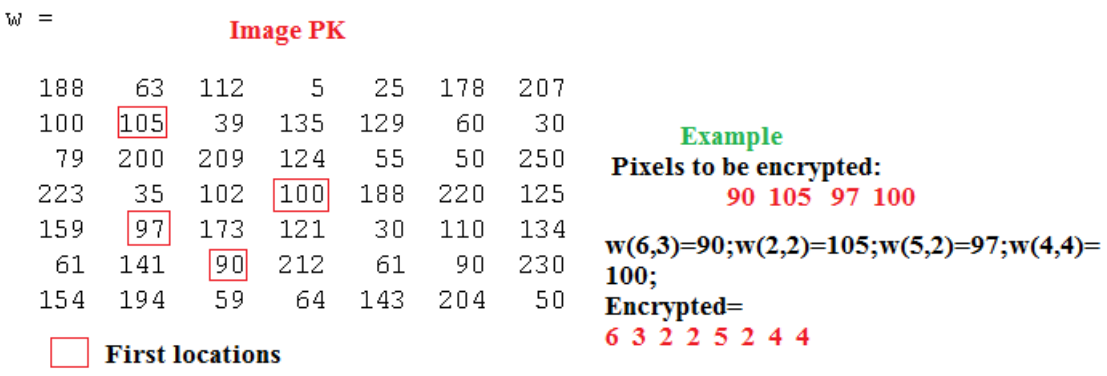

Figure 6: Pixels values encoding

Based on the above described operations the proposed method can be implemented applying the following sequence of operations:

Encryption phase:

Select the color image to be encrypted (a).
Private Key preparation.
Initialize 1 row matrix for the encryption image (b) with size equal size (a) multiplied by 2.
For each pixel value in (a) find the first appearance in the private key matrix, add the position row and column to the matrix b.
Get the encrypted image by reshaping image b to 3D matrix.
Decryption phase:

Get the encrypted image (e).
Private Key preparation.
Reshape the image matrix e to 1 row matrix (c).
Initialize the decryption matrix.
For each 2 positions in matrix c, get the row and column values.
Use the row and column number to get the value from the PK.
Add the value to the decrypted matrix.

Implementation and Experimental Results

The proposed method was programmed using matlab; the matlab code was implemented using various images, the image shown in figure 3 was selected and used as an image_key, then 10 images were encrypted-decrypted, figure 7 shows a sample outputs, while table 1 shows the obtained experimental results:

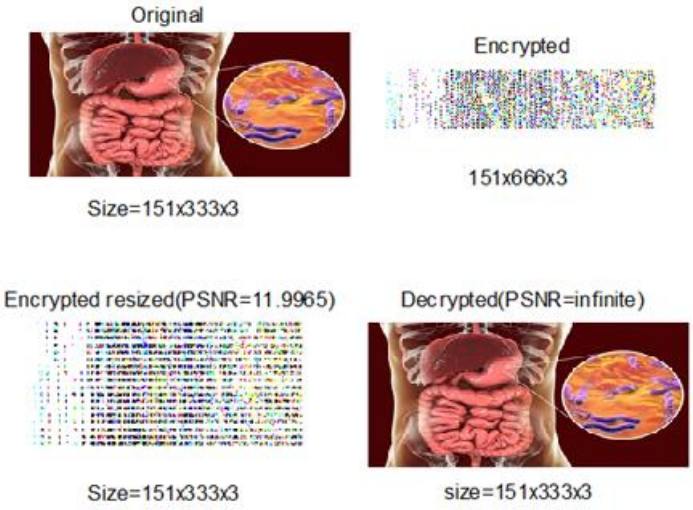

Figure 7: sample output

Table 1: Encryption-decryption results using image shown in figure 3 as a PK

MCI #	Size	Between original and encrypted images		Between original and decrypted images	
		MSE	PSNR	MSE	PSNR
1	150849	1.9592e+004	11.9965	0	Infinite
2	77976	1.8083e+004	12.7979	0	Infinite
3	518400	1.3265e+004	15.8963	0	Infinite
4	4326210	1.5020e+004	14.6539	0	Infinite
5	122265	1.0944e+004	17.8194	0	Infinite
6	518400	1.4818e+004	14.7892	0	Infinite
7	150975	1.6850e+004	13.5044	0	Infinite
8	150975	1.4072e+004	15.3055	0	Infinite
9	151353	1.5972e+004	14.0394	0	Infinite
10	1890000	1.7379e+004	13.1952	0	Infinite

The image key was replaced by the image shown in figure 8, and the same used images were treated using the proposed method, figure 9 shows a sample output, while table 2 shows the obtained experimental results.

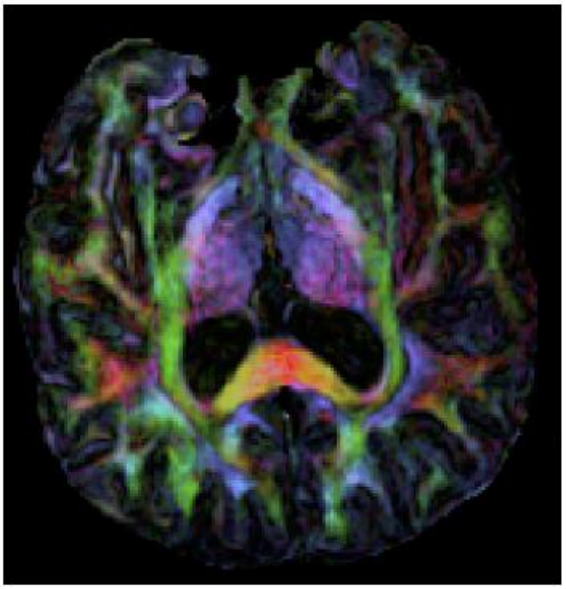

Figure 8: Another image_key

Table 2: Encryption-decryption results using image shown in figure 8 as a PK

MCI #	Size	Between original and encrypted images		Between original and decrypted images	
		MSE	PSNR	MSE	PSNR
1	150849	1.8178e+004	12.7456	0	Infinite
2	77976	2.1663e+004	10.9919	0	Infinite
3	518400	1.4664e+004	14.8935	0	Infinite
4	4326210	1.3036e+004	16.0702	0	Infinite
5	122265	1.1203e+004	17.5861	0	Infinite
6	518400	1.5475e+004	14.3554	0	Infinite
7	150975	1.3745e+004	15.5412	0	Infinite
8	150975	1.3254e+004	15.9045	0	Infinite
9	151353	1.7368e+004	13.2017	0	Infinite
10	1890000	1.5512e+004	14.3313	0	Infinite

The same images were encrypted decrypted using XORing operation and taking the image shown in figure 3 as a private key, table 3 shows the obtained experimental results.

From table 3 we can see that the proposed method enhanced the value of MSE and PSNR in the encryption phase, the proposed method increases the values of MSE and decreases the values of PSNR, which means that the proposed method degree of source image destruction is higher, thus will make the encrypted image more distortion.

Table 3: Results comparisons

MCI #	Size	Proposed: Between original and encrypted images		XORing: Between original and decrypted images	
		MSE	PSNR	MSE	PSNR
1	150849	1.9592e+004	**11.9965**	8.1878e+003	**20.7212**
2	77976	1.8083e+004	**12.7979**	1.0296e+004	**18.4301**
3	518400	1.3265e+004	**15.8963**	8.1138e+003	**20.8121**
4	4326210	1.5020e+004	**14.6539**	7.1759e+003	**22.0405**
5	122265	1.0944e+004	**17.8194**	7.1251e+003	**22.1114**
6	518400	1.4818e+004	**14.7892**	8.3525e+003	**20.5222**
7	150975	1.6850e+004	**13.5044**	7.8422e+003	**21.1525**
8	150975	1.4072e+004	**15.3055**	6.4201e+003	**23.1534**

9	151353	1.5972e+004	**14.0394**	7.8423e+003	**21.1524**
10	1890000	1.7379e+004	**13.1952**	7.6212e+003	**21.4384**

Conclusion

A simple method of MCI cryptography was proposed, this method is highly secures by using a secret color image as a private key, this key can be used to encrypt-decrypt any image with any size. The private key can be easily changed when the need arise. The proposed method gave excellent value for MSE and PSNR after implementing the encryption phase, and recovered the original source image after implementing the decryption phase. The proposed method was compared with other existing methods of data cryptography, and the proposed method gave more distortion of the source image by generating the encrypted image.

References

[1]. Majed O Al-Dwairi, Ziad A Alqadi, Amjad A Abujazar, Rushdi Abu Zneit, Optimized true-color image processing, World Applied Sciences Journal, vol. 8, issue 10, 2010, pp. 1175-1182.

[2]. Jamil Al Azzeh, Hussein Alhatamleh, Ziad A Alqadi, Mohammad Khalil Abuzalata, Creating a Color Map be used to Convert a Gray Image to Color Image, International Journal of Computer Applications, vol. 153, issue 2, 2016, pp. 31-34.

[3]. Qazem Jaber Ziad Alqadi, Jamil azza, Statistical analysis of methods used to enhance color image histogram, XX International scientific and technical conference, 2017.

[4]. Bassam Subaih Ziad Alqadi, Hamdan Mazen, A Methodology to Analyze Objects in Digital Image using Matlab, International Journal of Computer Science & Mobile Computing, vol. 5, issue 11, 2016,pp. 21-28.

[5]. Mazen A.Hamdan Bassam M.Subaih, Prof. Ziad A. Alqadi, Extracting Isolated Words from an Image of Text, International Journal of Computer Science & Mobile Computing, vol. 5, issue 11, 2016, pp. 29-36.

[6]. Dr. Amjad Hindi, Dr. Majed Omar Dwairi, Prof. Ziad Alqadi, Analysis of Procedures used to build an Optimal Fingerprint Recognition `System, International Journal of Computer Science and Mobile Computing, vol. 9, issue 2, 2020, pp. 21 –37.

[7]. Aws AlQaisi, Mokhled AlTarawneh, Ziad A. Alqadi, Ahmad A. Sharadqah, Analysis of Color Image Features Extraction using Texture Methods, TELKOMNIKA, vol. 17, issue 3, 2019, pp. 1220-1225.

[8]. Ahmad Sharadqh Naseem Asad, Ismail Shayeb, Qazem Jaber, Belal Ayyoub, Ziad Alqadi, Creating a Stable and Fixed Features Array for Digital Color Image, IJCSMC, vol. 8, issue 8, 2019, pp. 50-56.

[9]. Ziad Alqadi, Dr. Mohammad S. Khrisat, Dr. Amjad Hindi,Dr.Majed Omar Dwairi, VALUABLE WAVELET PACKET INFORMATION TO ANALYZE COLOR IMAGES FEATURES, International Journal of Current Advanced Research, vol. 9, issue 2, 2020, pp. 2319.

[10]. Ziad AlQadi, M Elsayyed Hussein, Window Averaging Method to Create a Feature Victor for RGB Color Image, International Journal of Computer Science and Mobile Computing, vol. 6, issue 2, 2017,pp. 60-66.

[11]. Bilal Zahran Belal Ayyoub, Jihad Nader, Ziad Al-Qadi, Suggested Method to Create Color Image Features Victor, Journal of Engineering and Applied Sciences, vol. 14, issue 1, 2019, pp. 2203-2207.

[12]. Ahmad Sharadqh Naseem Asad, Ismail Shayeb, Qazem Jaber, Belal Ayyoub, Ziad Alqadi, Creating a Stable and Fixed Features Array for Digital Color Image, IJCSMC, vol. 8, issue 8, 2019, pp. 50-56.

[13]. Yousf Eltous Ziad A.Al Qadi,Ghazi M. Qaryouti, Mohammad Abuzalata,ANALYSIS OF DIGITAL SIGNAL FEATURES EXTRACTION BASED ON KMEANS CLUSTERING, International Journal of Engineering Technology Research & Management, vol. 4, issue 1, 2020, pp. 66-75.

[14]. 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, 2020, pp. 48-55.

[15]. 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, 2019, pp. 4092-4098.

[16]. Ziad Alqadi, Majid Oraiqat, Hisham Almujafet, Salah Al-Saleh, Hind Al Husban, Soubhi Al-Rimawi, A New Approach for Data Cryptography, International Journal of Computer Science and Mobile Computing, vol. 8, issue 8, 2019, pp. 30-48.

[17]. Ayman Al-Rawashdeh, Ziad Al-Qadi, Using wave equation to extract digital signal features, Engineering, Technology & Applied Science Research, vol. 8, issue 4, 2018, pp. 1356-1359.

[18]. Aws Al-Qaisi, Saleh A Khawatreh, Ahmad A Sharadqah, Ziad A Alqadi, Wave File Features Extraction Using Reduced LBP, International Journal of Electrical and Computer Engineering, vol. 8, issue 5, 2018, pp. 2780-2787.

[19]. Jihad Nader Ismail Shayeb, Ziad Alqadi, Jihad Nader, Analysis of digital voice features extraction methods, International Journal of Educational Research and Development, vol. 1, issue 4, pp. 49-55, 2019.

[20]. 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, 2019, pp. 76-90.

[21]. Ziad Alqadi, Ahmad Sharadqh, Naseem Asad, Ismail Shayeb, Jamil Al-Azzeh, Belal Ayyoub, A highly secure method of secret message encoding, International Journal of Research in Advanced Engineering and Technology, vol. 5, issue 3, 2019, pp. 82-87.

[22]. Musbah Aqel Ziad A. Alqadi, Performance analysis of parallel matrix multiplication algorithms used in image processing, World Applied Sciences, vol. 6, issue 1, 2009, pp. 45-52.

[23]. Jihad Nadir, Ashraf Abu Ein, Ziad Alqadi, A Technique to Encrypt-decrypt Stereo Wave File, International Journal of Computer and Information Technology, vol. 5, issue 5, 2026, pp. 465-470.

[24]. Musbah J Aqel, Ziad ALQadi, Ammar Ahmed Abdullah, RGB Color Image Encryption-Decryption Using Image Segmentation and Matrix Multiplication, International Journal of Engineering and Technology, vol. 7, issue 3, 2018, pp. 104-107.

[25]. Belal Zahran Rashad J Rasras, Ziad Alqadi, Mutaz Rasmi Abu Sara, B Zahran, Developing new Multilevel security algorithm for data encryption-decryption (MLS_ED), International Journal of Advanced Trends in Computer Science and Engineering, vol. 8, issue 6, 2019, pp. 3228-3235.

[26]. Majed O Al-Dwairi, A Hendi, Z AlQadi, An efficient and highly secure technique to encrypt-decrypt color images, Engineering, Technology & Applied Science Research, vol. 9, issue 3, 2019, pp. 4165-4168.

[27]. Amjad Y Hendi, Majed O Dwairi, Ziad A Al-Qadi, Mohamed S Soliman, A novel simple and highly secure method for data encryption-decryption, International Journal of Communication Networks and Information Security, vol. 11, issue 1,2019, pp. 232-238.

[28]. Ziad A AlQadi, Accurate Method for RGB Image Encryption, International Journal of Computer Science and Mobile Computing, vol. 9, issue 1, 2020, pp. 12-21.

[29]. Ziad Alqadi, Majid Oraiqat, Hisham Almujafet, Salah Al-Saleh, Hind Al Husban, Soubhi Al-Rimawi, A New Approach for Data Cryptography, International Journal of Computer Science and Mobile Computing, vol. 8, issue 9, 2019, pp. 30-48.

[30]. Jamil Al-Azzeh, Ziad Alqadi, Qazem Jaber, A Simple, Accurate and Highly Secure Method to Encrypt-Decrypt Digital Images, JOIV: International Journal on Informatics Visualization, vol. 3, issue 3, 2019, pp. 262-265.

[31]. Dr Saleh A Khawatreh Dr Majed, Omar Dwairi, Prof. Ziad Alqadi, Dr. Mohammad S. Khrisat, Dr. Amjad Hindi, Digital color image encryption-decryption using segmentation and reordering, International Journal of Latest Research in Engineering and Technology (IJLRET), vol. 6, issue 5, 2020, pp. 6-12.

[32]. Mutaz Rasmi Abu Sara Rashad J. Rasras, Ziad A. AlQadi, A Methodology Based on Steganography and Cryptography to Protect Highly Secure Messages, Engineering, Technology & Applied Science Research, vol. 9, issue 1, 2019, pp. 3681-3684.

[33]. 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, issue 5, 2016, pp. 125-131.

[34]. PROF. ZIAD A. ALQADI, A SIMPLE METHOD TO ENCRYPT-DECRYPT SPEECH SIGNAL, International Journal of Engineering Technology Research & Management, vol. 5, issue 2, pp. 44-52, 2021.

[35]. Ziad ALQadi, Analysis of stream cipher security algorithm, Journal of Information and Computing Science, vol. 2. Issue 4, 2007, pp. 288-298.

[36]. 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, 2019, pp. 14-26.

[37]. Musbah Aqel, Ziad A. Alqadi, Performance analysis of parallel matrix multiplication algorithms used in image processing, World Applied Sciences Journal, vol. 6, issue 1, 2009. pp. 45-52.

[38]. Amjad Y Hindi, Majed O Dwairi, Ziad A AlQadi, A Novel Technique for Data Steganography, Engineering, Technology & Applied Science Research, vol. 9, issue 6, 2019,pp. 4942-4945.

[39]. 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, 2019, pp. 4092-4098.

[40]. Bilal Zahran Belal Ayyoub, Jihad Nader, Ziad Al-Qadi, Suggested Method to Create Color Image Features Victor, Journal of Engineering and Applied Sciences, vol. 14, issue 1, 2019,pp. 2203-2207 .

[41]. Akram A Moustafa, 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, vol. 5, issue 5, 2009. pp. 355-362.

[42]. Rushdi Abu Zneit, Jamil Al-Azzeh, Ziad Alqadi, Belal Ayyoub, Ahmad Sharadqh, Using Color Image as a Stego-Media to Hide Short Secret Messages, International Journal of Computer Science and Mobile Computing, vol. 8, issue 6, 2019, pp. 106-123.

[43]. Bilal Zahran Belal Ayyoub, Jihad Nader, Ziad Al-Qadi, Suggested Method to Create Color Image Features Victor, Journal of Engineering and Applied Sciences, vol. 14, issue 1, 2019,pp. 2203-2207.

[44]. Mohammed Ashraf Al Zudool, Saleh Khawatreh, Ziad A. Alqadi, Efficient Methods used to Extract Color Image Features, IJCSMC, vol, 6, issue 12, 2017,pp. 7-14.

[45]. 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, 2008,pp. 211-214.

[46]. 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, 2019,pp. 4092-4098.

[47]. Ziad Alqadi, A practical approach of selecting the edge detector parameters to achieve a good edge map of the gray image, Journal of Computer Science, vol. 5, issue 5, 2009,pp. 355-362.

[48]. M. Abu-Faraj, and Z. Alqadi, "Image Encryption using Variable Length Blocks and Variable Length Private Key," International Journal of Computer Science and Mobile Computing (IJCSMC), vol. 11, Iss. 3, pp. 138-151, 2022.

[49]. M. Abu-Faraj, A. Al-Hyari, and Z. Alqadi, "A Dual Approach for Audio Cryptography," Journal of Southwest Jiaotong University, vol. 57, no. 1, pp. 24-33, 2022.

[50]. 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.

[51]. M. Abu-Faraj, K. Aldebei, and Z. Alqadi, "Simple, Efficient, Highly Secure, and Multiple Pur- posed Method on Data Cryptography," Traitement du Signal, vol. 39, no. 1, pp. 173-178, 2022.

[52]. M. Abu-Faraj, Khaled Aldebe, and Z. Alqadi, "Deep Machine Learning to Enhance ANN Per- formance: Fingerprint Classifier Case Study," Journal of Southwest Jiaotong University, vol. 56, no. 6 , pp. 685-694, 2021.

[53]. M. Abu-Faraj, Z. Alqadi, and K. Aldebei, "Comparative Analysis of Fingerprint Features Ex- traction Methods," Journal of Hunan University Natural Sciences, vol. 48, iss. 12, pp. 177-182, 2021.

[54]. 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.

[55]. 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.

[56]. 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.

