

New 2-D interleaving grouping LBC applied on image transmission

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ABSTRACT

The modern technologies of the image transmission look for ultra-reducing of the error transmission in addition to enhancing the security over a wireless communication channel. This paper is applied and discussed two different techniques to achieve these requirements, which are linear block code (LBC) and two-dimensions (2-D) interleaving approach. We investigate a new approach of 2-D interleaving that increases the security of the image transmission and helps to diminution the bit error probability (BER). Using an investigated 2-D interleaving grouping LBC approach on image transmission, the system achieves a higher-security information and a better BER comparing with the other systems. It was done by means of peak signal to noise ratio (PSNR) and histogram analysis tests. Simulation results state these enhancements.

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1. INTRODUCTION

Data transmission challenges several concepts due to transmit over wireless communication channels. There are various impairments could affect the data transmission like interference, fading, and multipath propagation. Multimedia data and especially the image is suffered from the impairments when traveling over the wireless channels leading to increase the chance of occurring error [1]-[3].

Data interleaving technique grouping with LBC could be a significant solution to mitigate these issues by improving the performance, quality, and security of the image transmission system. Interleaving of the image data is necessary to minimize the burst errors occurred from the wireless communication channels [1], [4]. There are many types of interleaving systems have been proposed in [5], [6]. Block interleaving [7], [8] is a significant method to reduce the effects of the impaired channel on the data transmission. However, it is not an excellent technique for image transmission because of its ability to diminution one dimensional errors in the data transferring. Therefore, it is required the strength and 2-D interleaving system for error correction in the wireless communication system [9].

In this paper, we investigate a new approach of 2-D interleaving technique. Then, it is grouped with LBC, especially hamming code when it has an ability to correct single error and detect two errors which leads to implement it widely in many applications especially in digital communication, computing data compression [10]. This new technique could result in a better BER and PSNR than another system that is not utilizing the 2-D interleaving grouped with LBC or utilizing the other approach of interleaving.

The Hanpinitak and Charoenlarnpparut [11] presents the comparison of different kinds of two-dimension interleaves. It aims to discover an optimal interleave technique to process different errors that

result from various transmission environment. So according to the result of this paper, the prime interleave is a better than another type of two-dimensional interleave. While in the [12], it studies the performance of phase-shift keying technique modulation utilizing the error-correcting code through (AWGN) channel. In addition, the [1] deals with the comparison of the image transmission over the multi-carrier code division multiple access (MC-CDMA) techniques applying two kinds of interleaving: chaotic and helical interleaves to avoid wireless channel error. Moreover, the [13] presents and discusses the utilized of the chaotic interleaving technique to improve the image transmission over mobile wireless personal area network (WPAN) Bluetooth network and also compare the results with the case of using the conventional interleaves so the paper proves that the chaotic interleave is a better than the convolutional codes. Additionally, the researchers in [14] have proposed an efficient high-speed interleaved viterbi decoder architecture.

Our paper was organized is being as. Section 2 describes a new approach of 2-D interleaving process where grouping this new approach with the LBC process is described in section 3. Section 4 shows and discusses the simulation results. Finally, we conclude this paper in section 5.

2. 2-D INTERLEAVING

Interleaving is a process of scattering the information sequence based on a specific algorithm. It is popular in digital data information [6], [12], [15]. In this section, we consider a new approach of the interleaving process. A new interleaving approach achieves ultra-security of transmitting information and helps the coding process to detect and correct the error bits up to the interleaving index [16]. This new approach is a two-dimensional process, and it is grouping with LBC to get more benefits of interleaving technique. Hamming code (7, 4) is employed as LBC [17], [18]. For sake to the simplicity, we selected the interleaving index is equal to the length of the codeword, which is seven bits. Increasing the interleaving index altitudes, the difficultly of the interleaving and de-interleaving process. Therefore, we block the data bits into (7×7) blocks. For each block, the new interleaving approach is shown in (1-7).

$$InT(i, 1) = D(1, i) \quad (1)$$

$$InT(i, 2) = D(7, i) \quad (2)$$

$$InT(i, 3) = D(2, i) \quad (3)$$

$$InT(i, 4) = D(6, i) \quad (4)$$

$$InT(i, 5) = D(3, i) \quad (5)$$

$$InT(i, 6) = D(5, i) \quad (6)$$

$$InT(i, 7) = D(4, i) \quad (7)$$

Where $D(a, b)$ represents the data bit in a^{th} row and b^{th} column, and $InT(a, b)$ represents the interleaving bit. Due to these, each block of data bits is scattered as shown in Figure 1.

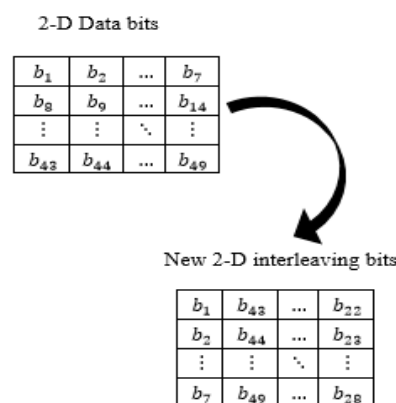


Figure 1. New 2-D interleaving approach

As shown in Figure 2, each sequential seven interleaving bits likes a random scattering, which increases the security of the data transmission. Furthermore, this approach gives more security and reliability than a block-wise interleaving and a bit-wise interleaving [11], [19]. The de-interleaving process is an inverse operation of the interleaving process.

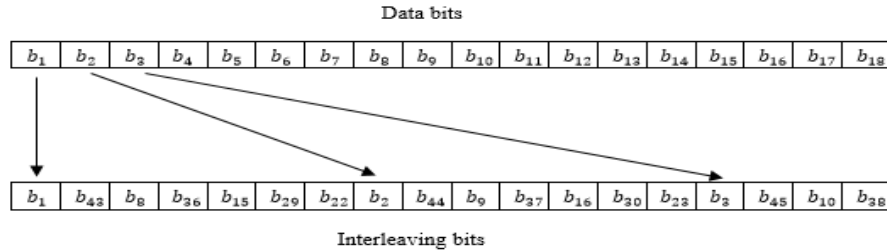


Figure 2. Sequential interleaving bits

3. NEW 2-D INTERLEAVING GROUPING LBC

This section describes the investigated system that employs a new 2-D interleaving grouping LBC to reduce BER by detection-correction error bits. Figure 3 shows this system [11]. The coding technique, in general, is implemented for controlling error in digital communication system leading to reduce the BER and increase the system security [20]. Hamming code is one type of LBC having the ability to correct single error and detect two errors [21]. As shown in Figure 3, the sequence of message bits (k) is applying to the channel coding LBC and generating (n) bits of the codeword. Hamming code (7,4) where k=4 denoted to the message length or the number of information in each bit and n=7 denoted to the block or code length [22]. To implement a hamming code, it is requiring the generated matrix (G).

$$G_{k \times n} = [P_{k \times r} : I_{k \times k}] \tag{8}$$

$$G_{4 \times 7} = \begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 0 & 0 & 1 \end{bmatrix} \tag{9}$$

The *P* and *I* represent the parity and identity matrices respectively while $r = n - k = 7 - 4 = 3$ and it is the redundant bits. Then the codes are generated is being as (10):

$$U = G * D \tag{10}$$

where *D* is the image bits and *U* is the generated code [20]. The next operation as shown in Figure 3 is interleaved the coded messages using a new approach of 2-D interleave which is stated in more detail in section 2. Then modulating and transmitting this interleaved image through flat fading channel under Rayleigh distribution environments [23]. On the other side, the receiver is able to extract the coded image bits after demodulation and de-interleaving processes. Furthermore, the parity checks matrix (*H*) [20] which is another method for stating the relationship between the image bits and parity check bits, could express as:

$$H_{r \times n} = [I_{r \times r} : P^T_{r \times k}] \tag{11}$$

$$H_{3 \times 7} = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \end{bmatrix} \tag{12}$$

where P^T denotes to the party matrix transpose. For the decoding stage, the received code (r) may be suffered from noise so the Syndrome (S) has the ability to discover the error (e) from the error pattern table finding is being as [20].

$$S = eH^T \tag{13}$$

$$r = U + e \tag{14}$$

Then by utilizing (15) [20], the detector could determine if there is an error in the received code or not.

$$S = rH^T \quad (15)$$

If syndrome = 0 then there is no error in the received code while if the syndrome $\neq 0$ so error has occurred. Then it could utilize the error pattern to detect the error position from the error pattern table. It is clear that the LBC detects and corrects a single error in each codeword. Moreover, this investigated system enables to detect and correct the whole codeword received in error in each block of data bits.

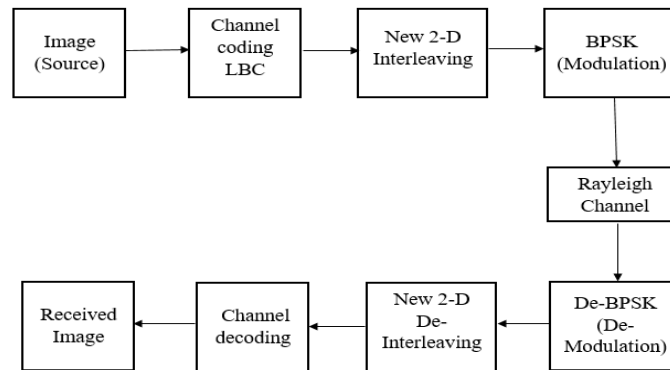


Figure 3. Investigated system

4. SIMULATION RESULTS

This section shows and discusses the computer results using MATLAB simulation. Figure 4 shows BER of the image transmission systems with and without 2-D interleaving grouping LBC. The result shows the system, which employs 2-D interleaving grouping LBC, significantly performs better than the other simple system due to using Hamming code where it is basically normal. Additionally, a new 2-D interleaving approach helps to reduce BER more as shown in Figures 5 and 6.



Figure 4. BER of the image transmission systems

As shown in Figure 6, the number of the occurred error bits is equal to or larger than the actual error bits for the system employing LBC only because each codeword has more than single error bit. In case of employing a new 2-D interleaving grouping LBC approach, the actual number of the error bits is detected and corrected while the maximum number of the error bits, that is detected and corrected, equals to the interleaving index as states earlier. If seven sequential bits are received in error. The new 2-D interleaving approach separates the seven error bits to get a single error bit in each codeword. This process helps LBC to detect and correct all number of error bits that is equal to or less than the interleaving index. Figure s 7 and 8 state the image transmission steps for the various values of the average signal to noise ratio with and without employing new 2-D interleaving grouping LBC and their histogram, respectively.

The results clearly show that the investigated system performs the best with increasing the average signal to noise ratio. As shown in Figure 7(b), new 2-D interleaving approach achieves excellent security. There is no receiver can detect this transmitted image without having knowledge about the interleaving approach and the interleaving index. As stated earlier, this value can be chosen depending on the channel fading environments, and the simplicity of the system. Moreover, two parameters are utilized in this paper to determine the reconstructed image quality and compare the received image with the original one.

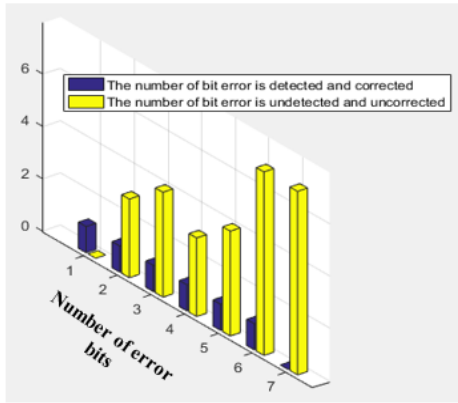


Figure 5. Number of error bits for a simple system

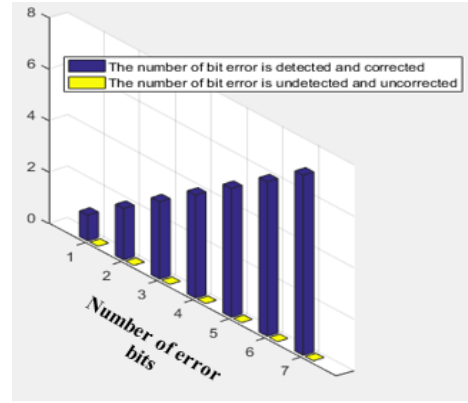


Figure 6. Number of error bits for new 2-D interleaving grouping LBC system

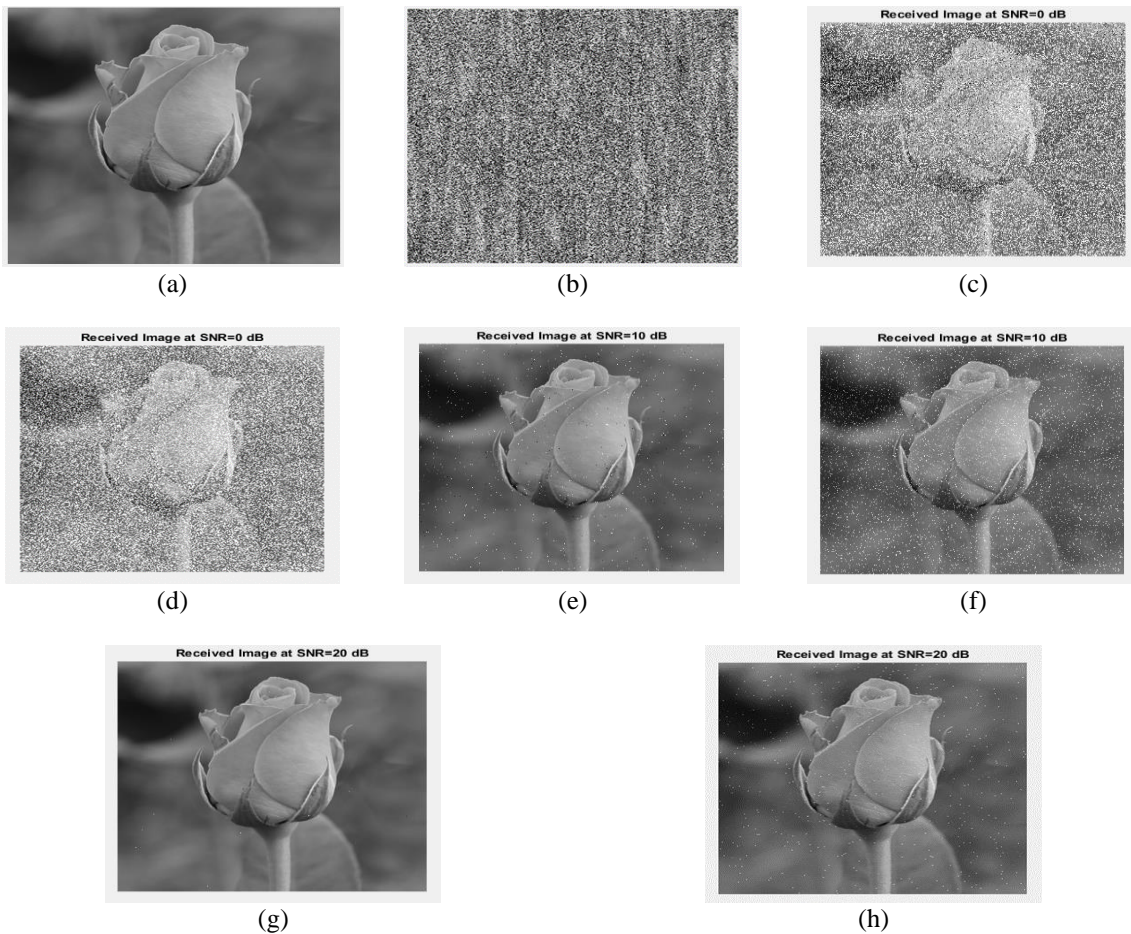


Figure 7. Images transmission steps for various SNR value; (a) original image, (b) transmitted image in the investigated system, (c) from investigated system, (d) from simple system, (e) from investigated system, (f) from simple system, (g) from investigated system, (h) from simple system

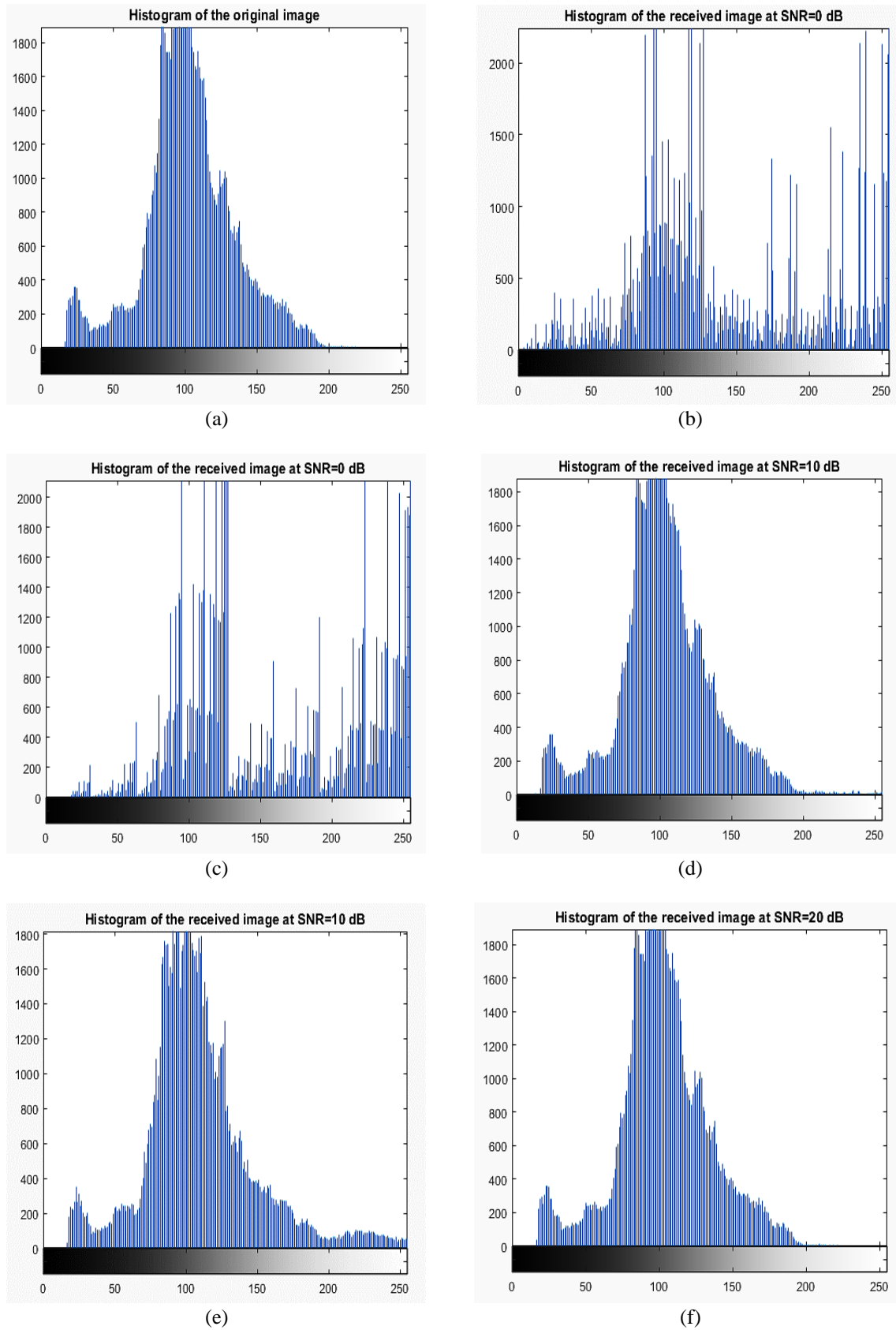
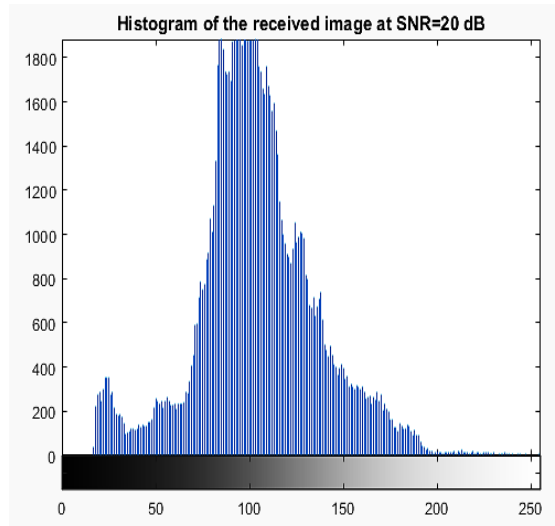


Figure 8. Histogram of image transmission, (a) histogram of the original image, (b) from investigated system (c) from simple system, (d) from investigated system, (e) from simple system, (f) from investigated system (g) from simple system (continue)



(g)

Figure 8. Histogram of image transmission, (a) Histogram of the original image, (b) from investigated system (c) from simple system, (d) from investigated system, (e) from simple system, (f) From investigated system (g) From simple system

4.1. Peak signal-to-noise ratio (PSNR)

PSNR is one method to determine the image quality and could define as the ratio of maximum possible signal power to the corrupting noise power that impacts on the signal reliability [24], [25].

$$PSNR(dB) = 10 \log_{10} \frac{P^2}{MSE} \tag{16}$$

Where P represents the maximum value of the pixel. The MSE calculate the cumulative MSE between the original and the recreated image.

$$MSE = \frac{1}{R \times C} \sum_{f=0}^{R-1} \sum_{g=0}^{C-1} [X(f, g) - \hat{X}(f, g)]^2 \tag{17}$$

The R and C are denoted to the pixel number in each row and in each column of the image respectively. While f and g represent the numbers of each row and column. Finally, $\hat{X}(f, g)$ is a reconstructed image and $X(f, g)$ is the transmitted image [26]. To be more accurate about the image transmission, Peak signal to noise (PSNR) value is calculated for each received image in different value of the average signal to noise ratio for both the investigated and simple systems as shown in Table 1.

Average signal to noise ratio	PSNR value of received image	
	Investigated system	Simple system
0 dB	10.1401	9.6795
5 dB	18.9478	15.2100
10 dB	28.5885	20.3816
15 dB	38.1868	25.4302
17 dB	42.4273	27.5969
20 dB	46.4844	30.6291

4.2. Histogram analysis

The aim of this method is to appear the statistical properties of sending image are not affected in the new examined system comparing with the simple system. Hence, if the results display that there are no differences between the histogram of the transmitted image and reconstructed image meaning that the new examined system could survive from the attackers. Figure 8 represented the histogram of transmitted and reconstructed of image for different values of SNR [27], [28].

5. CONCLUSION

Data transmission has been suffered from many challenges due to traveling over wireless communication channels. The main issue in data transmission is to enhance security and BER without reducing the data rate of a communication system. Therefore, in this paper, the investigation of new approach 2-D interleaving grouping with LBC especially hamming code is designed and applied on the image transmission system. The simulation results appear that the new investigation system is presenting a significant enhancement on the image transmission in term of achieving extraordinary security information and improve BER simultaneously. In addition, the comparison of the results between two systems, with and without employing new 2-D interleaving grouping LBC, is shown great improvement in security and BER for new 2-D interleaving grouping LBC. It is capable to implement this new technique in massive multiple input and multiple output (MIMO) communications systems. It may be significantly improved their performance.

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