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SIMULATION OF MEDICAL DATA COMPRESSION AND TRANSMISSION THROUGH WLANS

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ABSTRACT

Therefore, the main objective of this study is to develop a new simulation application for medical data compression and transmission based Wi-Fi IEEE 802.11 with high robust in term of image quality endurance to noise caused by transmission signal. The development of two main modules, namely, Wi-Fi transmission and medical data compression modules is required to achieve this objective. The focus of the study is to find a new method of medical data compression that has good ability to transmit the medical data even though any noise occurs during data transmission. The Wi-Fi transmission module was developed based on IEEE 802.11b protocol in 1 Mbsp data size transmission. The medical data compression modules were developed based on shared dictionary data between sender and receiver part. The shared dictionary was computed by Independent component analysis (ICA) using each type of medical data. In this study, tree type of data was used to generate shared dictionary: natural image, ultrasound image and fundus image. The performance evaluation includes two parts for the measurement of the error during simulation. First, the performance results related to the transmitted and received data similarity that represented by an error bit. The second performance results are regarded as the similarity between original image before and after transmitted that computed using a peak signal noise ratio (PSNR). The developed compression shows promising results with a capability of restoring image with PSNR 30 dB using medical image. In conclusion, this research has achieved its stated goal of developing a simulation application for medical data compression and transmission based Wi-Fi IEEE 802.11b.

Keywords: *DCT, SPIHT, PCS, ICA, MEDATA-SIM, Medical Image Compression*

1. INTRODUCTION

1.1 Overview

In medical data transmission or knowingly as telemedicine, we want to transfer data from one place to another and also to store the data for future purpose. The medical data transmission that used in the simulation. Since the size of the medical data such as image, movie or signals is too high, so a compression method must be performed before transmitted the data. In the case of medical images since the quality of the image is very important [1]. Different transformation techniques were used for compression of medical images. Compression is needed for medical images for some applications such as profiling patient's data or transmission systems [2]

1.2 Block Diagram

Figure 1 shows the Block diagram of the proposal compression schema (PCS), separated parts can be processed separately as per the requirement. Source data can be classified into general image, medical image and medical movie. In addition, Compress segment (CS) part will be processed by lossy and lossless technique with accepted compression methods, while Transmission/ Receiver Segment (TRS) will be processed using Wi-Fi 802.11n with low-cost, Low-bandwidth transmission. Finally, the Outcome Segment (OTS) will be for decompression and results analysis.

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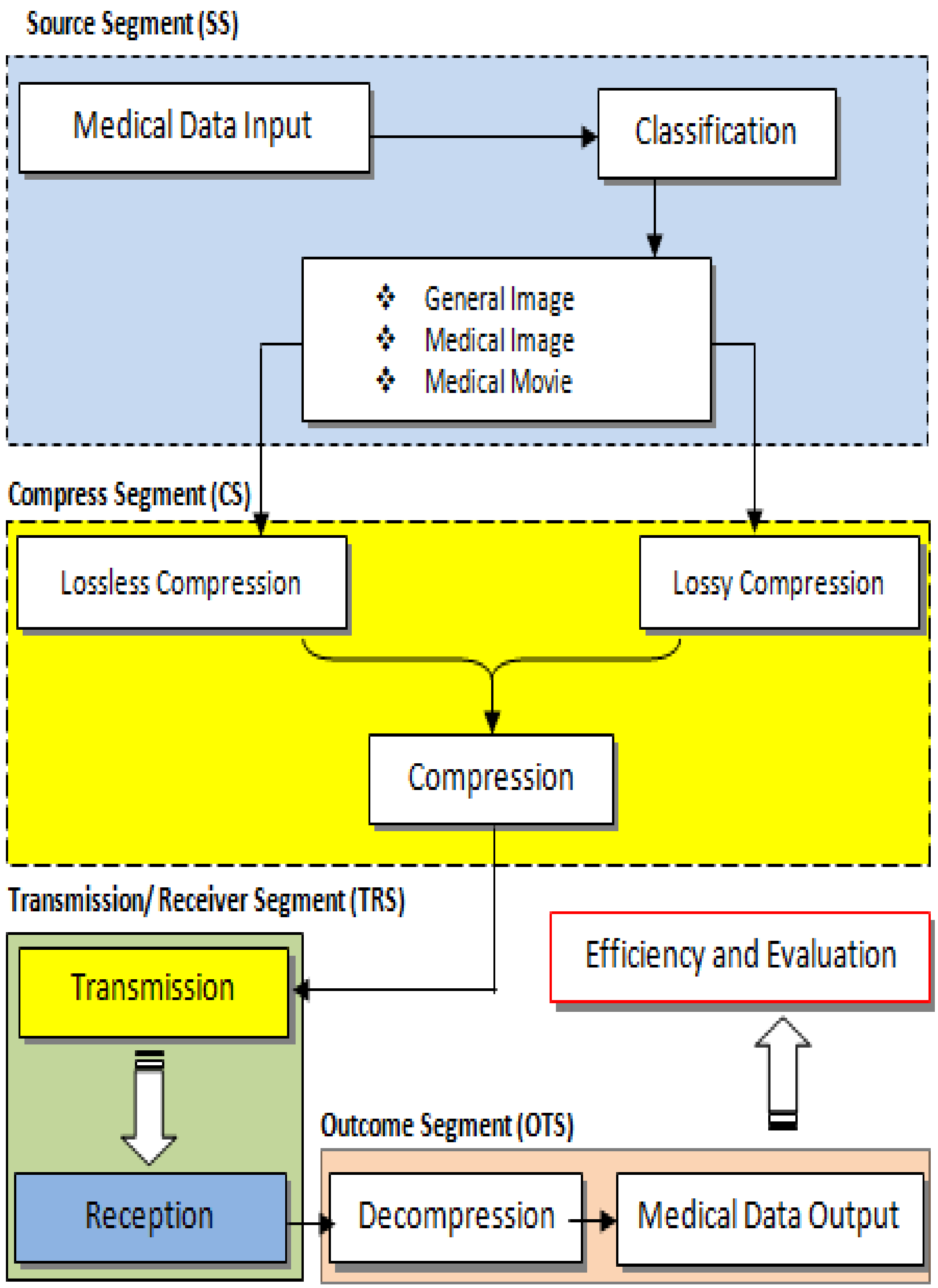

Figure 1 Block Diagram And Overview Of The Proposal Compression Schema (PCS)

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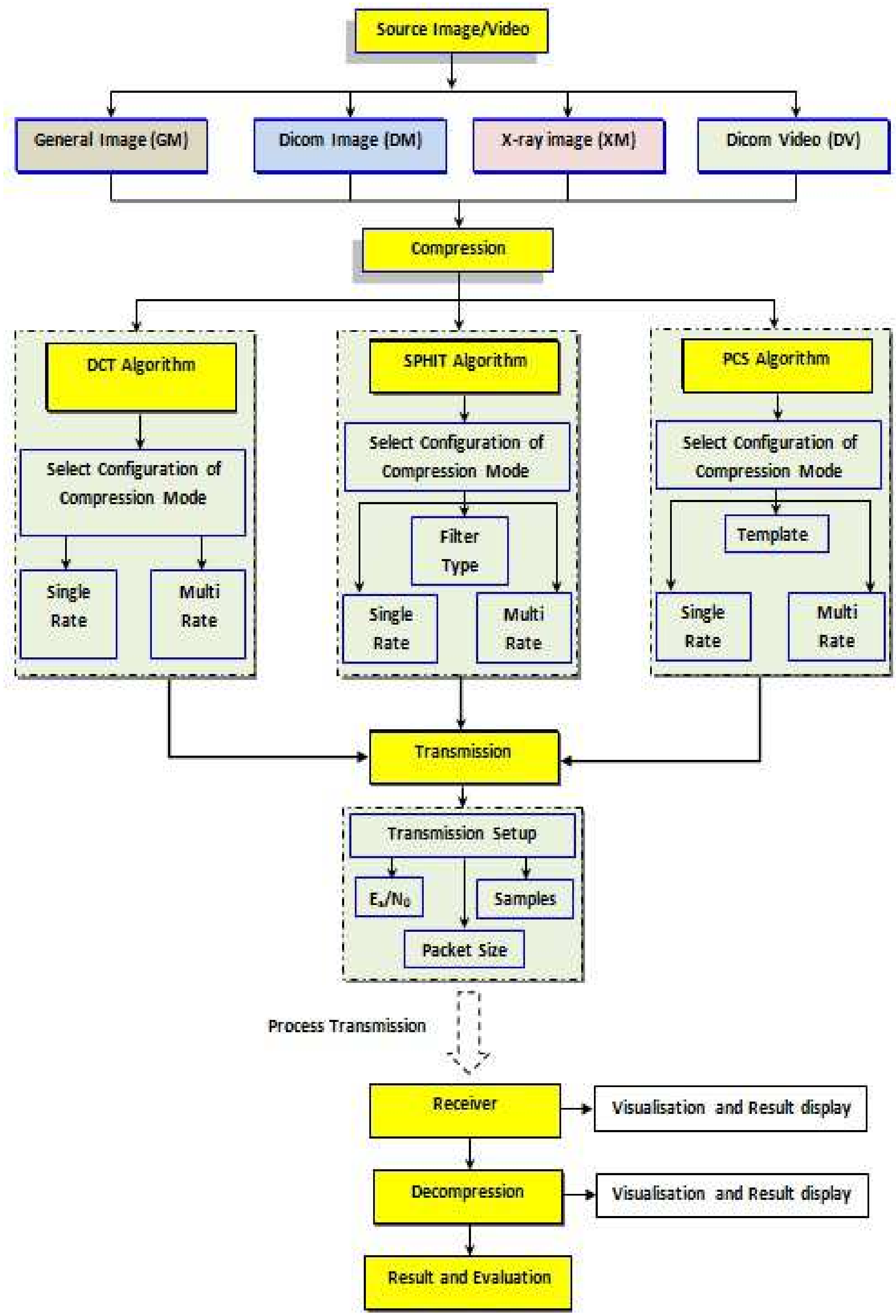

Figure 2 Block Diagram Of The Proposal Compression Schema (PCS) Methodology

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1.3 Simulation Schema

Figure 3 shows the detail of simulation schema of medical data transmission through Wi-Fi protocol. The first step is data conversion that convert any type of data (such as image, signal) to bits in binary form. Then we arrange the data in stream form that explained in next sub chapter. DBPSK (differential binary phase-shift keying) modulation was performed in the data in approaching the Wi-Fi protocol. Chips factor us sampling and filtering was applied to the modulation data stream before transmitted data. During data transmission, additive white Gaussian noise was added that representing the real condition of which noise occurs in Wi-Fi transmission due to electromagnetic interference with other apparatus or electric system [3]

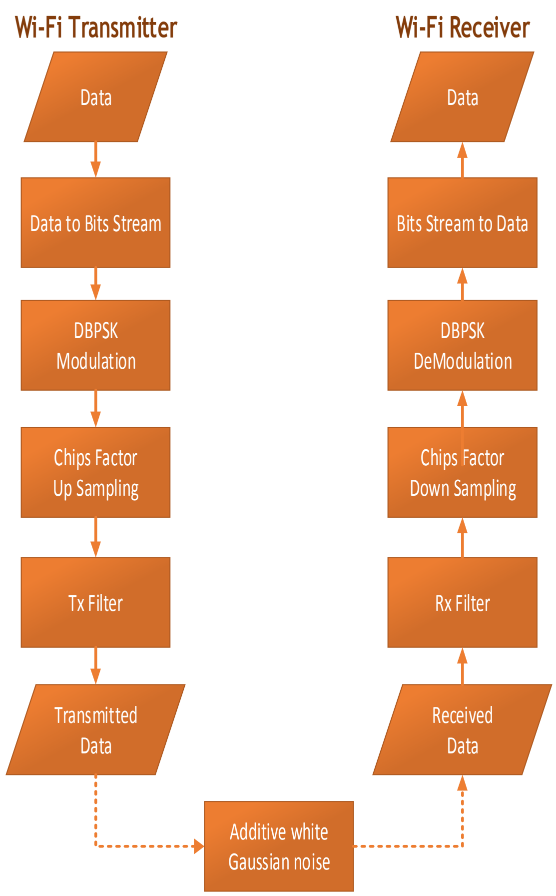

Figure 3: Simulation Schema Of Medical Data Transmission Through Wi-Fi Protocol

1.4 Proposed Image Compression

Compression is useful because it helps reduce the consumption of expensive resources, such as hard disk space or transmission bandwidth. On the downside, compressed data must be decompressed to be used, and this extra processing may be detrimental to some applications. Data Compression can be defined as reducing of the amount of storage space required to store a given amount of data. Data compression comes with a lot of advantages. It saves storage space, bandwidth, cost and time required for transmitting data from one place to another. Compression can be lossy or loss-less. With a loss-less compression and decompression, the original and decompressed files are identical bit per bit. On the other hand, compression efficiency can be improved by throwing away most of redundant data, without however losing much quality.

The outline of the medical image compression approach presented in this paper is illustrated in

Figure .

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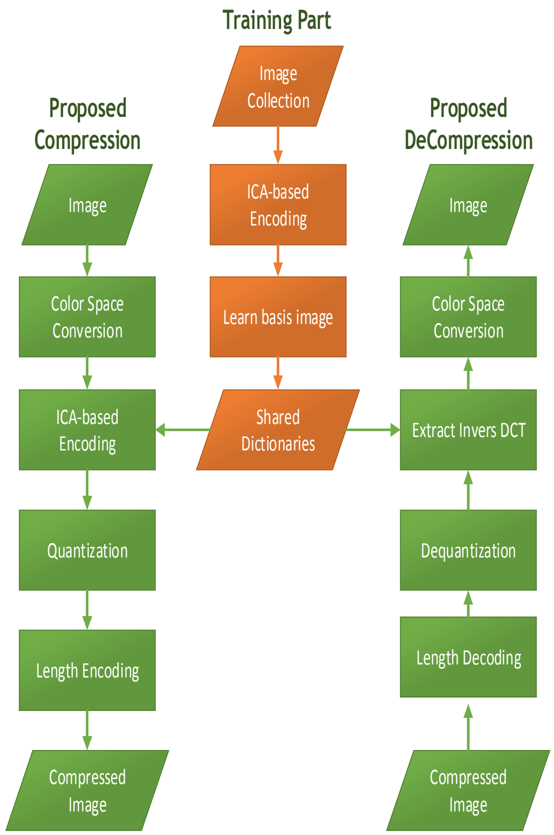

Figure 4 Block Diagram Of Medical Data Compression

1.4.1 ICA-based compression

The ICA method uses higher-order statistics to project the data into a new subspace whose vectors are as statistically independent as possible. These both techniques have been successfully applied in image processing, psychometric measurements, among other applications [4]

Independent component analysis (ICA) considers a class of probabilistic generative models in which an observed random vector X can be expressed as:

$$X = A.S \tag{1}$$

where A is a mixing matrix and S is a vector of containing independent sources. This model can be applied to the grayscale values of images; each sample of X usually contains the pixels in an image block.

ICA-based compression involves four steps. (1) Learning ICA basis vectors from the training images by applying Fast ICA. (2) Calculating the inverse or pseudo inverse of bases matrix, we call the obtained matrix W. (3) Preprocessing the image which is to be compressed. First, we divide the image into small square blocks (8×8). Each block is a column of matrix X0. Then, we subtract local mean and reduce the dimensionality by Principal Component Analysis (PCA).[5] At last, we obtained matrix X. (4) Obtaining the independent sources S according to:

$$S = W.X \tag{2}$$

where W and X are obtained by step (2) and step (3) respectively.

The compression step was continued by setting zero coefficient percentage. Only the elements with significant values are reserved while others are set to zero.

$$S = \begin{cases} S_0(i,j) & if\ S_0(i,j) > 0 \\ 0 & if\ S_0(i,j) < 0 \end{cases} \tag{3}$$

1.4.2 Quantization

The output of ICA coefficient was compressed by quantization approach. Quantization is the process of reducing the number of bits needed to store an integer value by reducing the precision of the integer [6]. Given a matrix of ICA coefficients, we can generally reduce the precision of the coefficients more and more as we move away from the DC coefficient. This is because the farther away we are from the DC coefficient, the less the element contributes to the graphical image, and therefore, the less we care about maintaining rigorous precision in its value.

In this part, Quantization is achieved by dividing each element in the ICA [7] matrices S by the corresponding element in the quantization matrices and then rounding to the nearest integer value as follow

$$SQ = round\left(\frac{\left(-1+2^{Q}\right)\left(S-S_{\min}\right)}{S_{\max}-S_{\min}}\right) \tag{4}$$

where Q is number of quantization. S, S_{min} and S_{max} denote the value, the minimum and the maximum value of ICA matrices, respectively. The value quantization Q of 8 was chosen in this research. Using the above equation, each element in the ICA matrices SQ will in range 0 to 255.

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255	128	110	113	128	122	123	126
67	40	140	148	120	126	129	126
3	212	125	97	128	129	116	130
49	72	109	143	109	129	120	123
0	66	193	113	148	115	120	130
34	216	106	120	128	112	120	123
99	143	72	148	107	128	128	122
46	169	110	110	155	123	125	128

(b)

Figure shows an example of the ICA matrices before and after quantization process. From the formula, one can notice the smaller ICA coefficients divided by the range ICA coefficients values will most often result in the low coefficients being rounded down to zero.

92	3	-9	-7	3	-1	0	2
-39	-58	12	17	-2	2	4	2
-84	62	1	-18	3	4	-5	5
-52	-36	-10	14	-10	4	-2	0
-86	-40	49	-7	17	-6	-2	5
-62	65	-12	-2	3	-8	-2	0
-17	14	-36	17	-11	3	3	-1
-54	32	-9	-9	22	0	1	3

(a)

255	128	110	113	128	122	123	126
67	40	140	148	120	126	129	126
3	212	125	97	128	129	116	130
49	72	109	143	109	129	120	123
0	66	193	113	148	115	120	130
34	216	106	120	128	112	120	123
99	143	72	148	107	128	128	122
46	169	110	110	155	123	125	128

(b)

Figure 5 Example Of The ICA Matrices, (A) Before And (B) After Quantization Process

1.4.3 Data encoding

The matrices of quantization are then encoded for the final step compression. Before transmitted, all elements of SQ are converted by encoder to a stream of binary data (0011001010…). This task was approached using the zig-zag sequence shown in Figure . The advantage lies in the consolidation of relatively large runs of zeros which compress very well. The sequence in Figure continues for the entire 8×8 block. [6]

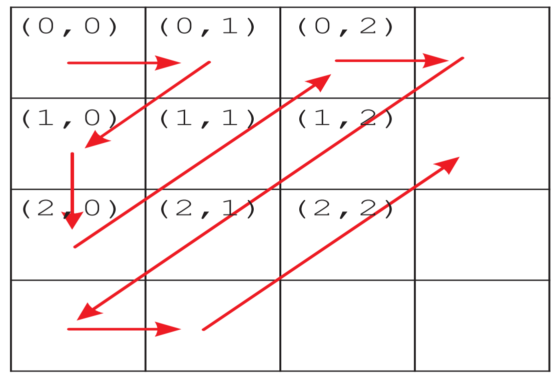

Figure 6 The Zig-Zag Encoder

Before and after encoding process using previous data. The output of this process is 1×n matrixes that contain a stream of data. In this simulation, each element is then converted in binary form using 8 bits of data.

255	128	110	113	128	122	123	126
67	40	140	148	120	126	129	126
3	212	125	97	128	129	116	130
49	72	109	143	109	129	120	123
0	66	193	113	148	115	120	130
34	216	106	120	128	112	120	123
99	143	72	148	107	128	128	122
46	169	110	110	155	123	125	128

(a)

255	128	67	3	40	110	113	140

128	155	123	128	123	122	125	128

(b)

Figure 7 Example Of The ICA Matrices, (A) Before And (B) After Encoding Process

1.4.4 Image reconstruction

After transmitted through Wi-Fi protocol connection, we get new bits stream data. We use invers of quantization and encoder method to encode bits stream data and produce a new independent source S∗. Reconstructing the image X∗ according to [8]

$$X^* = AS^* + E\left(X^o\right) \quad (5)$$

Where A and E (X^o) are the parameters that computed using the basis data of trained image.

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The parameter is shared between transmitter and receiver of medical data. In this research, the parameter is known as share dictionaries that show in

Figure .

1.5 Transmission Simulation

1.5.1 Data bits stream converter

Since data transmitted in bit format, the medical data were converted to bits stream before entering to the Wi-Fi simulation stage [9]. In this research, medical image is used as one of sample of medical data type. Bits stream of medical image were extracted from the pixel intensity value that involved of red, green and blue channel. The data are arranged as red, green and blue pixel respectively. 8 bit pixel intensity is represented by 1 byte data that consist of 8 binary data [10]. In case 16 bit pixel intensity, the data bits are represented by 2 byte data or 16 binary data.

Figure shows an example of bits stream conversion on ultrasound image which each pixel is represented by three layer of 8 bits pixel value. In this case of 8 bits, each pixel is converted to eight binary before and arranged as a series of data. The length of data series depend on the dimension of image or other medical data. In this research, the header of image file is not included in the simulation stage since our focus is to find the effect of image compression in Wi-Fi transmission protocol [11]

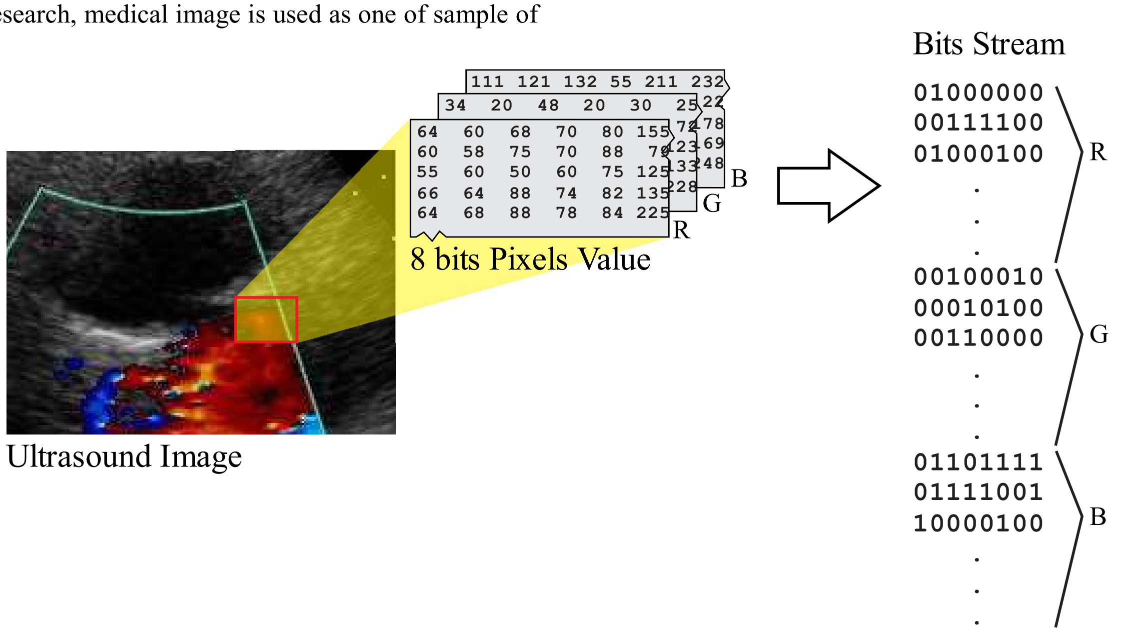

Figure 8: Example Of Bits Stream Conversion On Medical Image With RGB Channel

1.5.2 DBPSK modulation

The wireless LAN standard, IEEE 802.11b uses a variety of different PSKs depending on the data rate required [12]. At the basic rate of 1 Mbit/s, it uses DBPSK. To provide the extended rate of 2 Mbit/s, DQPSK (differential quadrature phase-shift keying) is used. In reaching 5.5 Mbit/s and the full rate of 11 Mbit/s, QPSK is employed, but has to be coupled with complementary code keying. The higher-speed wireless LAN standard, IEEE 802.11g has eight data rates: 6, 9, 12, 18, 24, 36, 48 and 54 Mbit/s. The 6 and 9 Mbit/s modes use OFDM (Orthogonal frequency-division multiplexing) modulation where each sub-carrier is BPSK modulated. The 12 and 18 Mbit/s modes use OFDM with QPSK. The fastest four modes use OFDM with forms of quadrature amplitude modulation.

1.5.3 Gaussian noise

A white Gaussian noise was added to the transmitted signal that assuming 0 db of input power [13]. The noise affect the transmitted data which in the binary format. The value of some

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transmitted data changed from 1 to 0 or 0 to 1 due to the white Gaussian noise. In this simulation, the medical data stream is divided into packet bits size. Therefore, the noise affects each packet data transmitted through the Wi-Fi. [14]

Figure shows example of the white Gaussian noise effect on bits stream using various level of noise.

The white Gaussian changes the value of bits from 0 to 1 or vice versa. It effects to the medical data that change some information in image or signal transferred through Wi-Fi connection.

11100000011011111010000000000000000000000
(a)
11110000000111111011001001010010100110000
(b)
111000100111111111100000000011101100000110
(c)

Figure 9: Example Of Gaussian Noise, (A) Original Bit Stream, (B) Bit Stream With 5 Db Gaussian Noise And (C) Bit Stream With 5 Db Gaussian Noise

1.6 Performance Evaluation

The performance evaluation includes two parts for the measurement of the error during simulation schema. First, the performance results related to the transmitted and received data similarity that represented by an error bit. The second performance results are regarded as the similarity between original image before and after transmitted that computed using a peak signal noise ratio (PSNR). The goal of an image quality measure is to provide a quantitative score that capture the similarity (or, conversely, the error) between an original version (reference image) and a distorted one [3]

1.6.1 Error bits

An error bit between the transmitted and received data was used to evaluate the proposed schema that sends compression medical data through Wi-Fi. In this research, the error is simulated by white Gaussian noise that added during the data transmission. The error bits was computed as [15]

$$error = \frac{\sum_{i=0}^{N} b_i \otimes b_i'}{N} \quad (6)$$

where b and b' are the bit stream before and after transmitted, respectively.

1.6.2 Peak signal noise ratio

A peak signal noise ratio (PSNR) was used to evaluate the quality of image that comparing the received and the original image. The PSNR is computed as

$$PSNR = 10\log\frac{peakval^2}{MSE} \quad (7)$$

where *peakval* is taken from the range of the image data type that used 8 bits of image. MSE is the mean square error between the received and the original image.

The MSE between two image a and b can be mathematically defined by

$$MSE(a,b) = \frac{1}{N}\sum_{i=1}^{N}(a_i - b_i)^2 \quad (8)$$

where N is the number of pixels in the images and a_i and b_i are the pixel values in the i-th position of the sample vector.

1.6.3 Simulation using random bit stream

In this part, Wi-Fi simulation was performed using random bits stream. Three types of random data with different size was generated using Matlab random function. Each data then used as data to simulate the Wi-Fi transmission. Figure shows the simulation result for this schema. The semi logarithmic approach was used to represent the BER value since it has very large range of value.

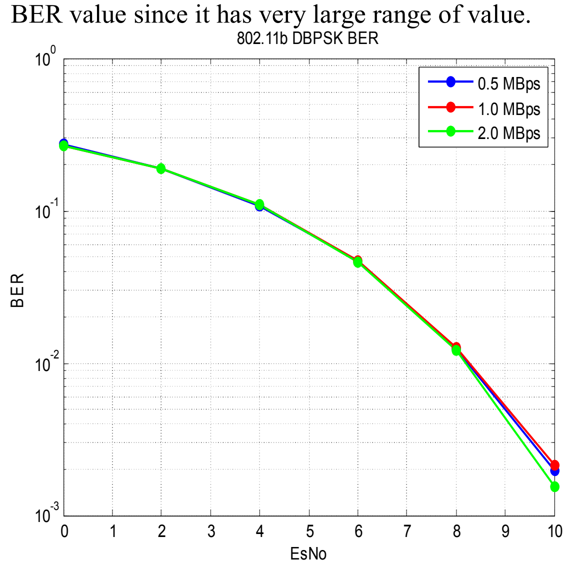

Figure 10: Simulation Result Of 802.11b Wi-Fi On 0.5, 1.0 And 2.0 Mbps DBPKS

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Based on the result shown in Figure , the bigger EsNo produces the lower BER value. The EsNo value denotes the level of noise applied to data transmission. Since the bigger data size transmitted through the Wi-Fi protocol, the noise effects to the data more significant compared with the smaller data size. It produces the bigger error in received data and the smaller BER value.

1.7 Data Transmission Simulation Result

In this section, experiment result of data transmission simulation is demonstrated using RGB natural image and grayscale radiography image. The experiment was performed using simulation schema that described in previous chapter. In this experiment, the PSNR and BER value are also computed to see the noise effect during transmission that simulate using AWGN noise generator.

1.7.1 DCT based data transmission

This section shows the performance of the DCT based data transmission. The simulation schema is applied on several types of images: natural images and medical images such that the performance of algorithm can be verified for medical applications. The retrieve image after data transmission is shown in Figure .

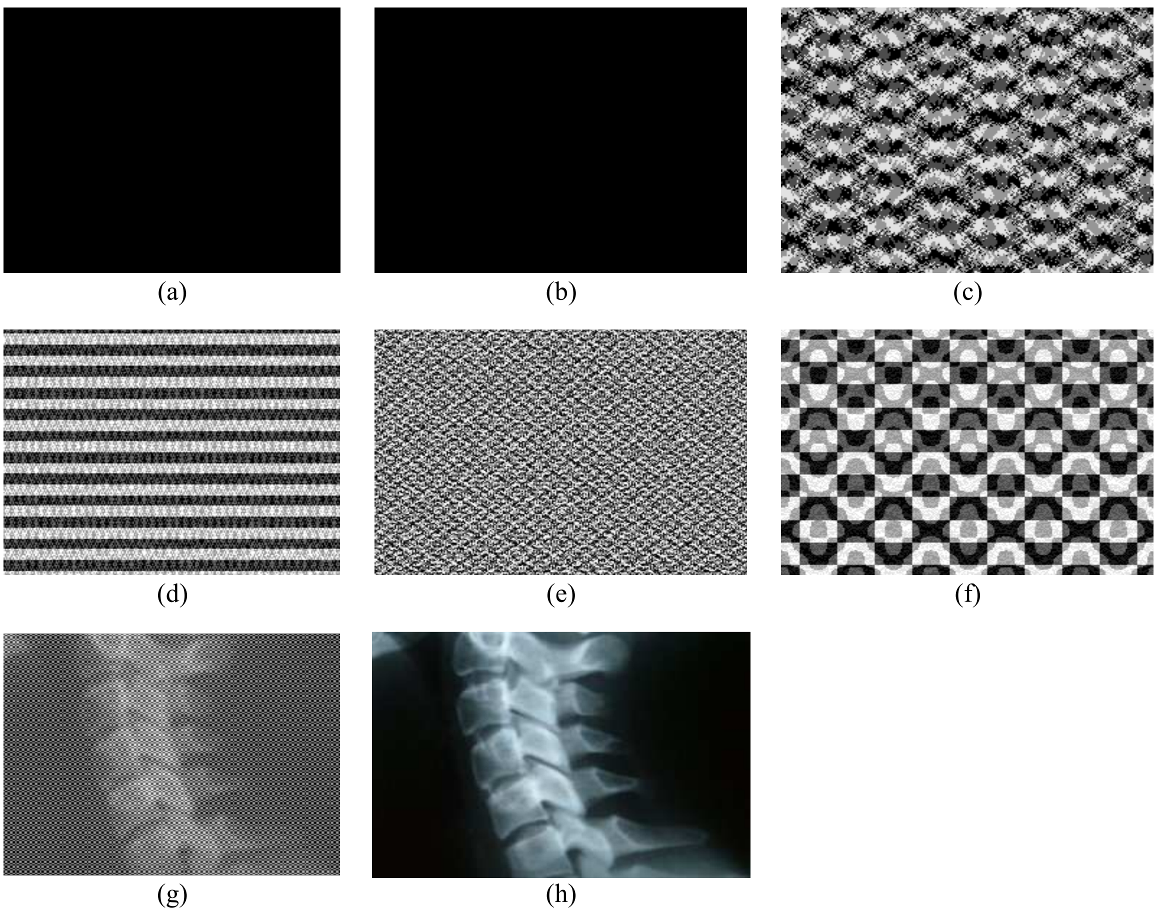

Figure 11 Data Transmission Simulation Using DCT Image Compression On Grayscale Radiography Image With Various Es Number: (A) 0 db, (b) 2 db, (c) 4 db, (d) 6 db, (e) 8 db, (f) 10 db, (g) 12 db and (h) 14 db

Figure shows the PSNR result on data transmission simulation using grayscale radiography image with various Es number. Based on the result, the lower Es number produces lower PSNR value.

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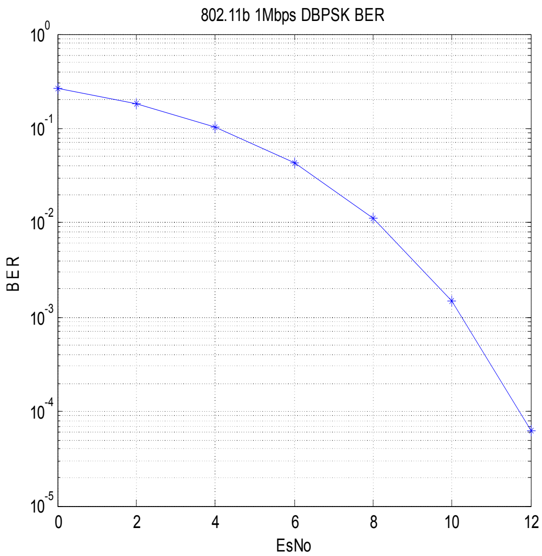


Figure 12: PNSR Result On Data Transmission Simulation Using DCT Image Compression On Grayscale Radiography Image

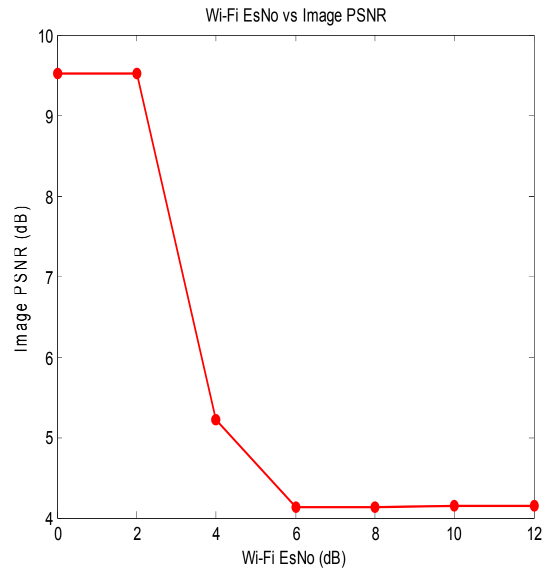
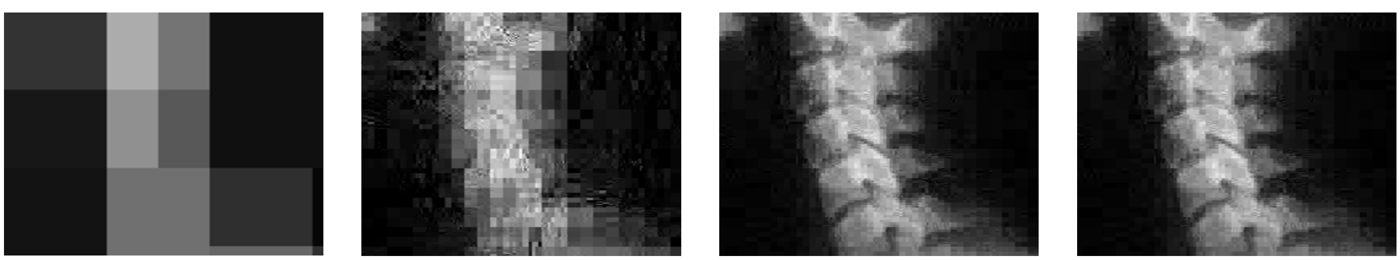


Figure 13: BER Result On 1 Mbps Wi-Fi Transmission Simulation Using DCT Image Compression On Grayscale Radiography Image

Figure shows the BER computation result on Wi-Fi transmission simulation using RGB natural image with various Es number in Mbps packet data.

1.7.2 SPIHT based data transmission

This section shows the performance of the SPIHT based data transmission. The simulation schema is applied on several types of images: natural images and medical images such that the performance of algorithm can be verified for medical applications. The retrieve image after data transmission is shown in Figure .



(a) (b) (c) (d)

Figure 14: Data transmission simulation using SPIHT image compression on grayscale radiography image with various Es Number: (a) 8 dB, (b) 10 dB, (c) 12 dB, (d) 14 dB

Figure shows the PSNR result on data transmission simulation using grayscale radiography image with various Es number. Based on the result, the lower Es number produces lower PSNR value.

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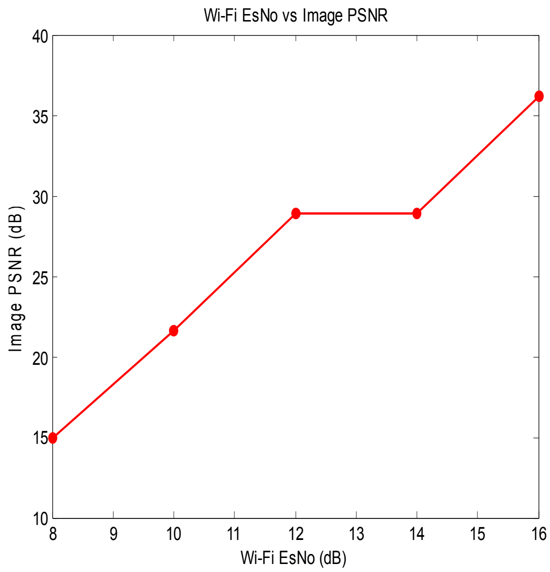

Figure 15: PNSR Result On Data Transmission Simulation Using DCT Image Compression On Grayscale Radiography Image

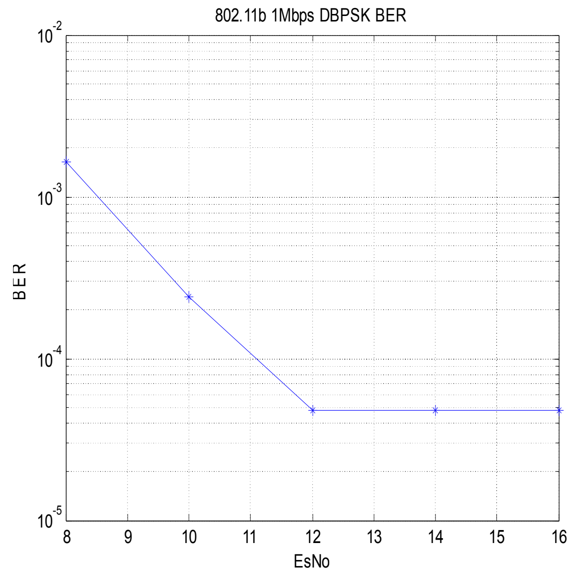

Figure 16: BER Result On 1 Mbps Wi-Fi Transmission Simulation Using DCT Image Compression On Grayscale Radiography Image

Figure shows the BER computation result on Wi-Fi transmission simulation using RGB natural image with various Es number in Mbps packet data.

1.7.3 Proposed method for data transmission

According to the proposed framework mentioned in previous chapter, our experiments including natural image and radiography image, Figure demonstrates data transmission simulation using radiography image on various Es number.

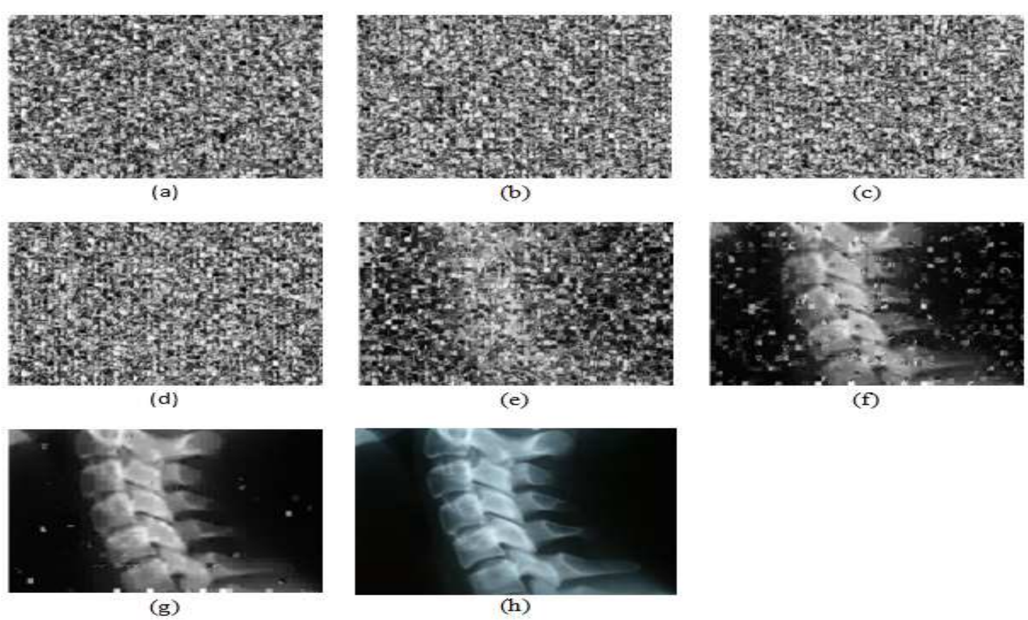

Figure 17 Data transmission simulation using proposed image compression on grayscale radiography image with various Es Number: (a) 0 dB, (b) 2 dB, (c) 4 dB, (d) 6 dB, (e) 8 dB, (f) 10 dB, (g) 12 dB and (h) original image

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Figure shows the PSNR result on data transmission simulation using grayscale radiography image with various Es number. Based on the result, the lower Es number produces lower PSNR value.

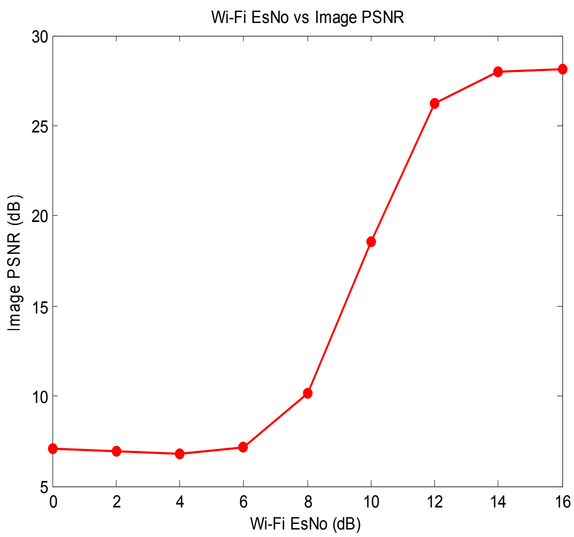

Figure 18: PNSR Result On Data Transmission Simulation Using Proposed Image Compression On Grayscale Radiography Image

Figure shows the BER computation result on Wi-Fi transmission simulation using RGB natural image with various Es number in Mbps packet data.

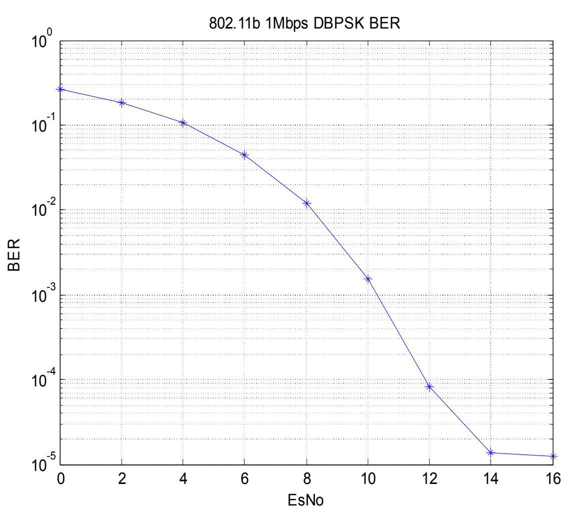

Figure 19: BER Result On 1 Mbps Wi-Fi Transmission Simulation Using Proposed Image Compression On Grayscale Radiography Image

REFERENCE

CONCLUSION

The necessity for valid, effective and practical image transmission system has become apparent as more healthcare professionals start to adopt this system in the course of their daily activities. Hence, the research field is rapidly expending even if building a project class system that is robust and reliable is very complex. Nevertheless, the benefit and profit that would be gained by the healthcare community are unimaginable. Therefore, I a new Medata-SIM system was successfully developed for medical data transmission/receiving using compression approaches with high robust in term of image quality endurance to noise caused by transmission signal and transmission based Wi-Fi IEEE 802.11b. The prototype system is developed for medical practitioner and is meant to allow them to transfer data from server to user. Thus, it will allow for an effective transmission which is significantly important in hospital network and medical data exchange

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CONTRIBUTIONS

A new Medata-SIM system architecture for medical data transmission via Wifi has been proposed and developed. The new architecture focuses on the compression, transmission and recevied segamnts which involves integration of diffent algorithms thus allowing a more robust and effective data trnamission. The new scheme implement data compression which have benefit to increase the transmission speed since it has lower size of data and the data throughput transmission can also be increase due to decreasing of data size. Forthermore, strong to noise that occur in Wifi transmistion and has benefit to handle sercurity issue in data transmission. In addition, a new GUI has been created for data transmission to facilitate the end-user to visualize the received images of their queries in making data exchange.

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