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Data Compression and Encryption for Remote Sensor Networks Using Different Techniques Methods

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ABSTRACT

Wireless sensor networks (WSNs) are widely used for the different multimedia applications in which the data in multimedia form (e.g., images and videos) are captured by visual sensors and transmitted to base stations or destination nodes, and such networks, commonly called wireless multimedia sensor networks (WMSN), transmit high-quality images over sensor nodes with image quality improvement and CS technique while the security of CS data is achieved. The one-way DF-based cooperative digital image transmission model over WSNs using advanced terminologies for image compression called advanced JPEG2000 compression and modified elliptical curve cryptography (ECC) encryption is proposed. Image quality improvement efficiency is essential in multimedia applications and wireless communications. The authors proposed a novel technique based on adaptive and dynamic noise removal and quality improvement for both before compression and after compression. The compression method designed is based on CS technique.

KEYWORDS

Compressive Sensing, Data Encryption, Energy Efficiency, Ratio, Remote Sensing

1. INTRODUCTION

Wavelet transform realizes the energy of the picture confined among theory and detailed pictures; the hard and fast vitality stays predictable. In lossy weight, loss of vitality occurs in light of quantization (B.Alhayani & H.Ilhan, 2010). The compaction of vitality depicts how much essentialness has been compacted into the evaluated picture during the wavelet examination. Compaction is gigantic when squeezing signs since, the more, the higher the imperativeness compaction into the assessed picture, the higher weight ampleness may be gotten (B.Alhayani &Milind Rane, 2014):

$$\left(C_{i,j}\right) = \begin{cases} \sqrt{\dfrac{1}{N}} cos\dfrac{\left(2j+1\right)i\pi}{2N}, \ i=0, j=0,1,\ldots,N-1 \\ \sqrt{\dfrac{2}{N}} cos\dfrac{\left(2j+1\right)i\pi}{2N}, \ i=0,1,\ldots,N-1, j=0,1,\ldots,N-1 \end{cases} \tag{1}$$

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Wavelet transform crumbles the sign into various sub-social occasions, all of which has it is very own spatial bearing combine that can be feasibly utilized for picture coding. In picture coding, this construes a quantization bungle from the coefficient won't stay limited to the area yet rather will spread through the duplicated picture with the condition of the looking at wavelet (B.ALhayani & Haci Ilhan, 2017). Wavelet transform offers various favourable circumstances, and wavelet coding has been at the point of convergence of the various states of craftsmanship picture coders. Wireless communication is one of the predominant modes used to share information from source to destination (H. Xua, K. Huan, & H. Wang, 2015). It has been growing rapidly in industrial, medical, education, and other developing sectors.

Wireless technologies are employed at radio frequencies for the information to be conveyed to the consumers quickly and without any loss. The messages are transferred through channels without any wires so that the work can be done anywhere and at any time (H. Yang et al,2010). The major applications of wireless technologies are in mobile telephones, radio receivers, telecasts, and wireless networking. Applications, such as video conferencing, require a high data rate to transport the information in a short time (J. M. Shapiro,1993). Though the increase in mobility of wireless communication technology is tremendous, the cost of the installation and maintenance of the wireless components needs to be minimized. Wireless signals are propagated into air with noise added into the signal. As a result, the signal strength is decreased, increasing the loss of data (J. N. Laneman, D. N. C. Tse, & G. W. Wornell, 2004). The primary goal of the wireless communication system is to limit the error and maximize the data rate or system capacity, especially in multimedia communications. Sensor hubs speak with one another through a radio connection in a multihop manner (J. N. Laneman & G. W. Wor- nell, 2002). They broadcast the measured event to the nodes present within their transmission range, and finally, the event reaches the network operator at the monitoring site. Sensor nodes broadcast the measured event only after in-network processing which makes it unsuitable for applications that deal with huge volume of data (J. Pappacha & J. Baby, 2015).

Wireless Multimedia Sensor Network (WMSN) belatedly has the idea of the examination network because of the progression of CMOS cameras. WMSN gives a vast extent of potential applications in both standard occupant and military areas which require visual data, for example, reconnaissance, natural and mechanical checking, savvy traffic blockage control, medicinal services, and green city applications (B. Alhayani & H. Ilhan, 2020). While there are many applications for WMSN, this thesis targets those applications in which the digital images are transmitted over WSNs. The overview of WMSN in which camera hubs are put in the observation zone to be checked. The captured video is transmitted to the monitoring site in a multihop manner using regular nodes. The availability of CMOS cameras has encouraged the advancement of WMSNs which comprises remotely interconnected multimedia capable sensor nodes. These multimedia sensor nodes extensively recover multimedia substances, for example, video and sound streams, still pictures, and scalar sensor data from nature. The mixed-media information collected from the environment is processed and transmitted (Khalaf, O. I., & Abdulsahib, G. M., 2019).

2. RELATED WORK

The image compression investigation aims to design a secure and energy-productive helpful compression picture Handling video data imposes a few challenges on the network such as high bandwidth demand, ongoing conveyance, mediocre start-to-finish postponement, and edge misfortune rate (J. M. Shapiro,1993). Additionally, there are numerous asset limitations in WMSNs, including vitality, band- width, information rate, memory, and preparing capacity. Security in sensor networks is a highly challenging job as it is used for sensitive applications such as surveillance, building monitoring, airports, and hospitals. These challenges can be met with the help of an efficient compression algorithm to handle high data rates and efficient security mechanisms for dealing with the security attack (Khalaf, O. I., & Sabbar, B. M., 2019). The Audio/video store, system snapshots, streaming media, play-back capacities have different capacities as for jitter, postponement, and misfortune lenience that require a new look at offering essential QoS services (Khalaf, O.I.et al.,2020).

The Bandwidth Strictly limited; WMSNs need transmission data transfer capacity that is much more than the capacity of reachable sensors. The Power utilization is the primary issue as multimedia functions create large volumes of information which need higher transmission rates and widespread dispensation than in conventional wireless sensor networks. The User monitoring facility, Addition to the internet. The protocol design is fundamentally large for the sensor systems to give benefits that permit scrutinizing the framework to recover supportive data. The Leveraging of in-network support Dispensed databases of multimedia information, counting dispensed memory and guiding of data inside the network itself, in-network routing systems require to be enlarged to extract appropriate information from current data resourcefully (Khalaf, O.I.et al. et al.,2018).

In MIMO of Wireless communication technology has developed rapidly due to the increase in the mobility of users. Different information yield system is one of the popular techniques in which numerous radio wires are utilized both, in the transmitter and the collector, to update the data rate. In the transmitter, the sign is transmitted from different radio wires at a similar recurrence. Various single and multi-user information yield innovations have been executed and created in IEEE802.11n products. There are special types of MIMO systems: Single Input Single Output (SISO), Single Input Multiple Output (SIMO), Multiple Input Single Output (MISO), and Multiple Input Multiple Output (MIMO). Multiple antennas are used to achieve array gain that increases the bandwidth efficiency, link reliability, the limit of the channel, and lessens the multipath blurring (Khalaf, O. I., & Abdulsahib, G. M., 2019). The fundamental point of the MIMO framework is to limit the likelihood of blunder and expand the transmission speed. The MIMO channel model with its multiple transmit antennas transmits multiple information at the same frequency; the information is sent to the matrix channel that has N number of ways between the transmitter and the beneficiary. The sign caught by the receiving antenna is decoded and then converted into the original information. and noise matrix respectively. Single and multi-user MIMO technology has been implemented and developed in IEEE 802.11n products. Mostly, it uses 2x2 and 3x3 MIMO systems. IEEE is a professional association that provides electronics and electrical technologies, and IEEE 802.11n is the standard that can maintain wireless networking with the help of IEEE, using the channel-based system. Based on the network operation, the frequency can be adjusted. It is the most complicated networking standard that is to be properly configured and optimized. IEEE 802.11n provides improved performance operating at 2.4 GHz and 5 GHz frequency band using two important technologies, namely, 40 MHz wide channels and 20 MHz channels in MIMO systems. MIMO has multiple transmit-and-get receiving wires to send and get the information, improving the performance significantly. IEEE 802.11n provides the maximum data rate of 150 Mbps (Khalaf, O. I., & Abdulsahib, G. M., 2019).

The 1x1 wireless devices use the single 802.11n standard transmit and receive antennas. The 2x2 MIMO product provides double the amount of data rate of 300 Mbps and is used in several applications, including mobile phones, because of the small size of the device, though installing multiple antennas in the device is difficult. If it is 1x1 MIMO configuration, the maximum data rate may be 72 Mbps for 20 MHz channel width and 150 Mbps for 40 MHz channel width. Similarly, the maximum data rate is 144 Mbps for 20 MHz channel width and 300 Mbps for 40 MHz channel width in 2x2 MIMO configurations. The Types of MIMO, (SISO) The framework with only one antenna at the input and one at the destination is known as the SISO framework. There is the utilization of single reception apparatus wire at the transmitter and the same at the beneficiary end. These systems are generally less complicated in comparison to multiple-input multiple-output systems. The Nyquist, root locus, bode, and Nichols are the different tools that are used for the analysis of SISO system (J. N. Laneman, D. N. C. Tse, & G. W. Wornell, 2004). (SIMO) The framework with only one antenna at the input and numerous elements at the destination is known as SIMO. To minimize errors and obtain speed of data, these elements may be combined. This technology finds applications in mobile communications and digital television (B.Alhayani & H.Ilhan, 2010).

(MISO) The framework which has multiple antenna elements at the input and one element at the destination is known as the MISO framework. This is also known as smart antenna technology. To improve the transmission distance, this approach is employed in the field of mobile communications. The advantages of MIMO, The Coverage range: Because of the impact of the coherent combining wireless framework, a gain of an array of average radio signals can be found as per enhanced signal-to-noise ratio at the destination which results in enhancement of ratio of resistance to noise. The impact of this factor will increase the covering radius of framework, High effect of diversity The power of the signal at the destination randomly varies in the remote framework. The powerful approach is diversity. Due to higher autonomous copies not less than single, there are no expands in fading thus augmenting the reliability and high quality of the signal (Khalaf, O.I.et al.,2020). Spatial multiplexing gain: MIMO framework gives a direct rise in capacity without the necessity of extra spectrum utilization or expansion in power transfer. With acceptable conditions of the channel, the elements at the destination can isolate information series. Moreover, every information stream channel experiences, in any event, the same quality as contrasted with a SISO framework to successfully enhance capacity with increased component equivalents of the quantity of series. By and large, it is conceivable to securely get the channel of MIMO that is equivalent to a little number of series of element at input and destination. In the present era, when people depend on wireless technology, the demand for high data rates in remote correspondence becomes even more. The number of clients who need this new technology has seen an upward increase. Wireless innovation has seen tremendous advances in the past years. However, some physical parameters of wireless technology need to be improved to offer optimum benefit to the clients. In most of the cases, battery life, restricted recurrence band, and serious blurring channels are causes that need to be addressed. Cooperative communication can help address the issue of longer battery life (Osamah I. Kh. et al.,2018). It is a framework where wireless mobiles can transmit their signals simultaneously, thus achieving a number of significant improvements in communication over multipath fading channels. These improvements include increased rates for data communication, enhanced clarity and coherence for voice communications, reduced transmission power, and expanded battery life. The essential guideline of helpful correspondence is using other correspondence devices to operate hand-off transmission (Osamah I. Kh. et al.,2018).

(H. Yang et al,2010) shows data broadcasting from the source node to both the nodes, i.e., destination node and relay hub. The hand-off centre at that point progresses the transmission to the endpoint center. The source centre point sees the exchange center as a virtual reception apparatus, empowering MIMO systems to be used without including a physical receiving wire. The size and power constraints of a mobile unit make it impossible to mount multiple transmit antennas, which limits the capacity of transmission from mobile units to base stations in existing mobile communication scenarios. This has driven the rapidly growing research on transmit antenna diversity to user cooperation. To achieve transmit diversity in the uplink, other in-cell clients' radio wires can be shared in an agreeable manner. This method of grabbing transmit of a decent variety is called cooperative diversity (CD). Cooperative diversity methods relieve the impacts of transient blurring just as the effects of long haul fading, i.e., shadowing, by choosing the partner who does not experience shadowing. In a cooperative diversity scheme, mobile users share the time or frequency and different assets to transfer the receiver's data to the recipient. For instance, as indicated in (H. Xua, K. Huan, & H. Wang, 2015), two mobile sensors (called sender and receiver) collaborate and transmit the information to the recipient. In the first stage, the sender transmits its data to both the destination and the receiver. In such communications, higher frequency components exhibit bad propagation characteristics while lower frequencies suffer from the problem of low data rates (B.Alhayani & H.Ilhan, 2010).

3. THE RESULT AND DISCUSSIONS

Image Compression and Encryption picture information is at that point transmitted over the remote AWGN with the probability of commotion addition, the image compression techniques can be used in this paper respectively.

3.1. Discreet Wavelet Transform (DWT)

This algorithm the four critical steps of their approach such as DWT and wavelet-based decomposition (M. Antonini et al,1992), pixel-position (PP) information and pixel-value (PV) information split based unequal image resource allocation (M. Nasri et al., 2010), In 1D-DWT, the basis picture s of size N is parcelled into two coefficients, for example, actuate coefficients CA1 and feature coefficients CD1. picture data occurrence, and along these lines, 2-D DWT is used. In multi-hope remote picture transmission frameworks, we need an effective information pressure technique with least information misfortune probabilities. In this manner, at the transmitter, we compacted the pre-handled picture utilizing 2D-DWT. 2D-DWT is broadly utilized in picture preparing applications: the guess at level j + 1, and the subtleties in three information (LL, LH, HL, HH) (M. Antonini et al., 1992):

$$\Psi_{a,b}\left(t\right) = \frac{1}{\sqrt{a}}\Psi\left(\frac{t-b}{a}\right) \tag{2}$$

where Ψ (t) has to satisfy the following conditions:

- Admissibility condition: $\int \left|\Psi\left(\omega\right)\right|^2 \left|\omega\right|^{-1} d\omega$

$\Psi\left(\omega\right)$ is the Fourier transform of $\Psi\left(t\right)$. It implies that $\left|\Psi\left(\omega\right)\right|_{\omega=0} = 0$ i.e. $\int \Psi\left(t\right) dt = 0$, which means that $\Psi\left(t\right)$ is zero mean and must be a wave.

- Regularity conditions: That the wavelet function ought to have some smoothness and focus in both time and frequency domains. DWT function given by equation 5 is obtained by putting $a = 2^{-j}$ and $b = k2^{-j}$ in Eq. 2:

$$\Psi_{j,k}\left(t\right) = 2^{1/2}\Psi\left(2^j t - k\right) \tag{3}$$

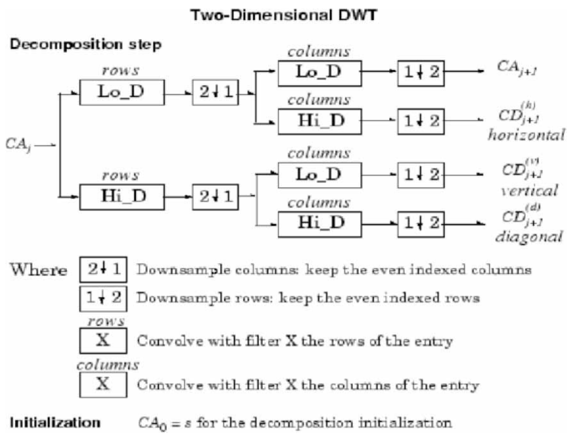
where the $\Psi_{j,k}$ constitute ortho-normal basis, i.e., wavelet coefficients of function f(t):

$$W_{j,k} = \int f\left(t\right)^{j/2}(2^j t - k) \text{ (analysis equation)} \tag{4}$$

The function f(t) can be reconstructed from wavelet coefficients as:

$$\text{F(t)} = \sum_j \sum_k W_{j,k} 2^{j/2}\Psi\left(2^j t - k\right) \text{ (synthesis equation)} \tag{5}$$

Figure 1. 2D-DWT Compression and Decomposition (J. M. Shapiro,1993)



The over two equations (equations 4 and 5) structures the mix and assessment state of a DWT. The DWT is finished utilizing channel banks as depicted in Figure 1 (J. M. Shapiro,1993).

There are two sorts of thresholding capacities, for example, hard thresholding and the delicate limit for wavelet denoising, Novel hybrid denoising method to get better the denoising execution. Design hybrid threshold-based wavelet denoising capacity can be definite as we proposed:

$$I_1^R\left(i,j\right) = \begin{cases} sng\left(I_1^R\left(i,j\right)\right) * \left(\left|I_1^R\left(i,j\right)\right| - \alpha\right), & if\left(I_1^R\left(i,j\right) > \varepsilon\alpha\right) \\ 0, & else \end{cases} \tag{6}$$

where α is the base threshold esteem for smothering the clamor, ε is the additional alteration factor in the scope of $0 < \varepsilon < 1$, and $I_1^R\left(i,j\right)$ is the present estimation of the boisterous guess coefficient at the location (i, j). On the off chance that the location of squares failed, the present squares are unnecessary to forestall the picture data misfortune. On advancement, the re-QPSK and IFFT activities are implemented.

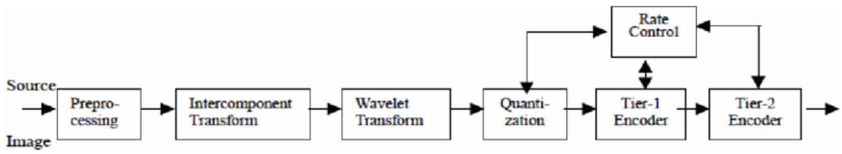
3.2. Optimized Joint Photographic Experts Group (JPEG 2000)

The base sensor communications reduce data transmissions and improve energy efficiency significantly. But another challenge while using the compression is data loss due to different security threats during the transmission. The compressed data at the receiver end is decompressed with poor quality, hence securing the compressed data by using the lightweight security method is important while planning the helpful picture transmission model. In this chapter, we propose our next research contribution to alleviate the challenges of security and energy efficiency for cooperative digital image transmission. The key highlights of this contribution are, Optimized JPEG 2000 introduced for the digital image compressed after the denoising to improve the image transmission performance as well as computational efficiency as shown in Figure 2 (Zeng, W., Daly, S., & Lei, S. 2002).

3.3. The Proposed Solution (optimized Encryption Cryptography)

The elliptic curve cryptography (ECC) Based technique further encrypts the compressed data (S. Xu, C. Li, F. Li & S. Zhang, (2012). The novelty of this method is that it achieves the trade-off between minimum energy consumption and strong security by modifying the optimized scalar multiplication tasks using a special random number as a scalar. This approach limiting the computational endeavors

Figure 2. JPEG2000 compression (Zeng, W., Daly, S., & Lei, S. 2002)



accomplishes higher security for compressed data. The complete wireless communication model designed using the BPSK modulation and Rayleigh fading channel for cooperative image transmission. Investigated image compression algorithms using image quality analysis element like PSNR, MSE. Performance evaluation of cooperative image transmission with best-in-class techniques exhibited as far as BER, MSE, energy efficiency, etc. are concerned, before presenting the proposed methodology design and algorithms, we first discuss the different types of digital data and file types that are transmitted over the WMSNs. Also, the various security threats.

After the image is compressed, the compressed data is more vulnerable to the different wireless channel threats. This paper addresses the security issues for compressed data by using the modified ECC-based cryptography method. The key problem of the conventional ECC method is the complicated and time-consuming task of scalar multiplication which may consume the extra energy of sensor nodes, so energy consumption is optimized by elaborating the steps of ECC-based encryption and decryption in the proposed ECC-based model (Chatterjee, S., & Das, A. K. ,2015). The technique JPEG 2000 image compacted shown in Figure 3.

4. SOLUTION AND ANALYSIS TECHNIQUE

The compression methods are evaluated in terms of many performance metrics for image mainly in two categories image quality parameter and compression quality parameter. The pressure procedure quality is assessed utilizing the CR parameter given in expression Figure. In this section, the CR rate evaluations are discussed. Table 1 (Figure 7) demonstrates the performance of the CR using different compression methods and proposed methods.

The ECC method is composed of three main tasks: key generation, encryption, and decryption. The computation efforts (time) required for key generation, encryption, and decryption are measured and compared with the existing ECC approach. Table 2 shows the average computation times needed for each phase. Note that the experiments were conducted on I3 processor and 4 GB RAM configurations:

$$PSNR = 10Log_{10}\left(\frac{R^2}{MSE}\right) \tag{6}$$

Anywhere M is info picture T and N is gotten picture D.

5. CONCLUSION

To enhance the performance for image quality and energy efficiency, the image compression technique. To protect the compressed image data, the lightweight ECC technique is suggested. On the off chance that the PSNR results demonstrate the technique as a look at state-of-craftsmanship picture send strategies show. The PSNR is improved cause of using DWT. ahead demonstrate the diagrams for various re-enactment arrangements.

Figure 3. The Input images Transmission compacted and received

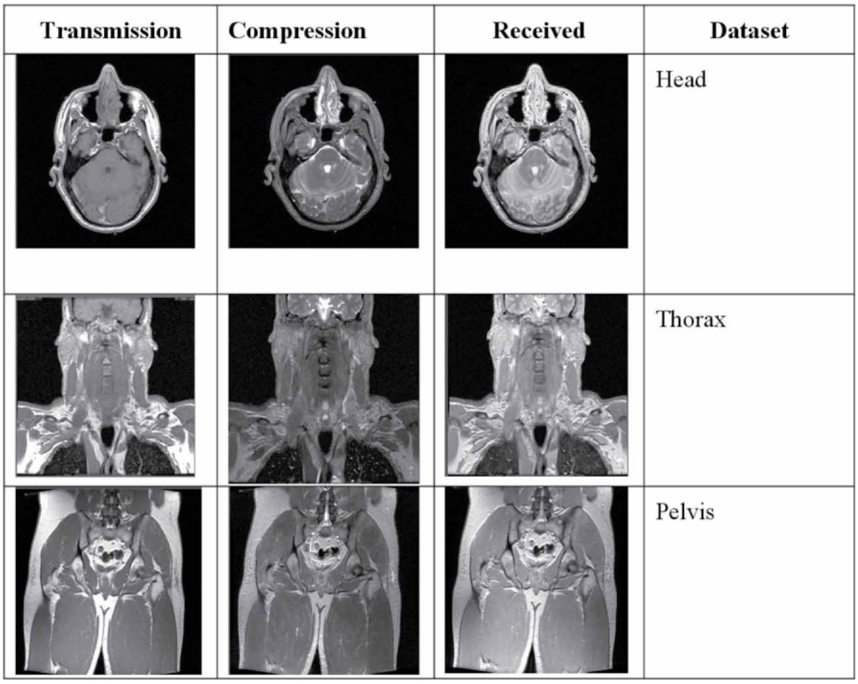


Table 1. Image Compression ratio evaluation

	1DWT	Run length	2DWT	JPEG2000
Head	1.75	2.95	9.34	11.95
Thorax	2.54	3.05	9.95	12.67
Pelvis	2.66	3.99	9.97	12.30

Figure 4. CR performance evaluations of different images

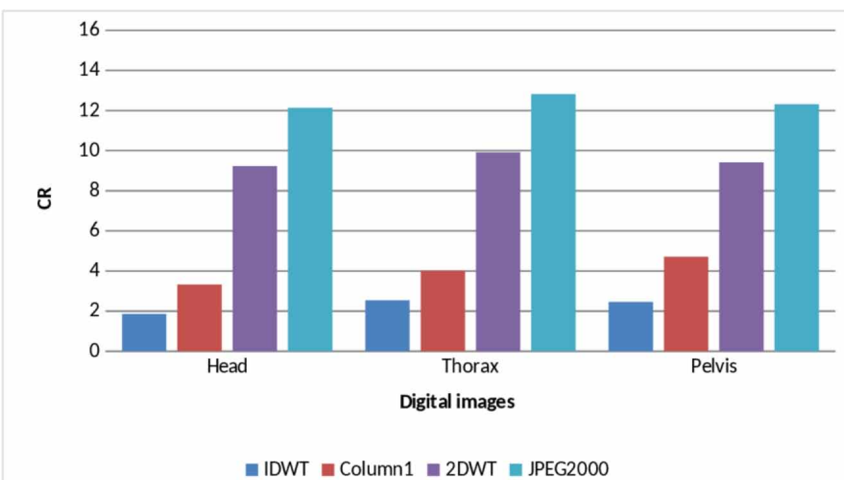


Table 2. Computation time analysis

	ECC (Sec.)	Modified ECC (Sec.)
Key generation	7.00	0.84
Encryption	2.01	2.22
Decryption	1.78	1.21

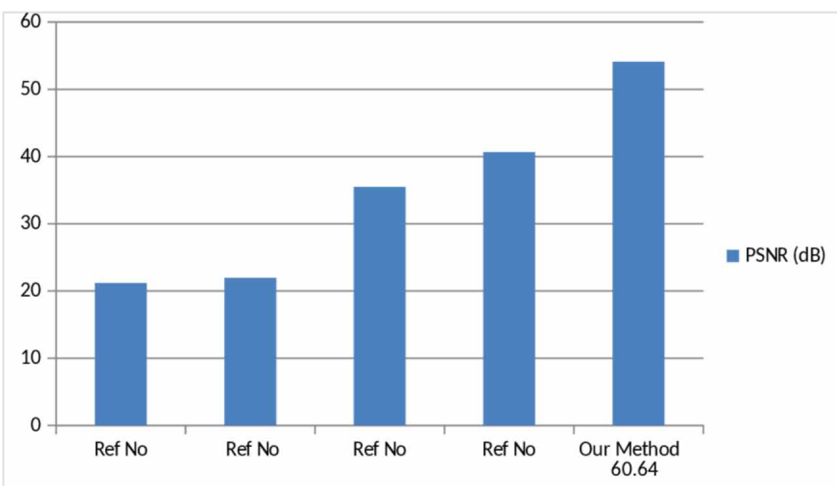
Table 3. Image quality Decompression

	MSE	PSNR	SSIM
Head	0.12	44.0	0.899
Thorax	0.16	44.02	0.899
Pelvis	0.18	42.51	0.899

Table 4. Average PSNR analysis With Other References

Algorithm	PSNR (dB)
(Khalaf, O.I.et al. et al.,2018)	21.18
(Khalaf, O. I., & Sabbar, B. M., 2019)	21.95
(Khalaf, O. I., & Abdulsahib, G. M., 2019)	35.47
(Khalaf, O.I.et al.,2020)	40.33
Our Method	54.08

Figure 5. Average PSNR Competitive



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