Quad Tree Decomposition Based Analysis of Compressed Image Data Communication for Lossy and Lossless Using WSN

N. Muthukumaran, R. Ravi

***Abstract*—**The Quad Tree Decomposition based performance analysis of compressed image data communication for lossy and lossless through wireless sensor network is presented. Images have considerably higher storage requirement than text. While transmitting a multimedia content there is chance of the packets being dropped due to noise and interference. At the receiver end the packets that carry valuable information might be damaged or lost due to noise, interference and congestion. In order to avoid the valuable information from being dropped various retransmission schemes have been proposed. In this proposed scheme QTD is used. QTD is an image segmentation method that divides the image into homogeneous areas. In this proposed scheme involves analysis of parameters such as compression ratio, peak signal to noise ratio, mean square error, bits per pixel in compressed image and analysis of difficulties during data packet communication in Wireless Sensor Networks. By considering the above, this paper is to use the QTD to improve the compression ratio as well as visual quality and the algorithm in MATLAB 7.1 and NS2 Simulator software tool.

***Keywords*—**Image compression, Compression Ratio, Quad tree decomposition, Wireless sensor networks, NS2 simulator.

I. Introduction

THIS document is, currently wireless sensor networks are beginning to be deployed at an accelerated pace. It won't be too far that the world will be covered with wireless sensor networks with access to them via the internet [1]. Recent technological advances have enabled the development of sophisticated wireless sensor nodes which have the ability to perform sensing, processing, communication and actuation tasks. A wireless sensor network is a collection of nodes organized into a cooperative network [1]. Each node consists of processing capability (one or more microcontrollers, CPUs or DSP chips), may contain multiple types of memory (program, data and flash memories), have a RF transceiver (usually with a single Omni-directional antenna), have a power source (e.g., batteries and solar cells), and accommodate various sensors and actuators. QTD can be applied through two alternative approaches; the first is bottom-up decomposition and second is top-down decomposition. However the top-down decomposition is considered to outperform bottom-up QTD for images. QTD has been widely used for its low complexity and powerful compression potential [8], [9].

Muthukumaran.N, Assistant Professor, is with the Department of Electronics and Communication Engineering, 103/G2, Bypass Road, Francis Xavier Engineering College, Vannarpettai, Tirunelveli, Tamilnadu, India - 627003, (Phone: +91 462 2502283, +91 9952203887; Fax: +91 462 2501007; e-mail: kumaranece@gmail.com).
Ravi Ramraj is Professor and Head, Department of Computer Science and Engineering, 103/G2, Bypass Road, Francis Xavier Engineering College, Vannarpettai, Tirunelveli, Tamilnadu, India - 627003, (Phone: +91 462 2502283, +91 9442418917; Fax: +91 462 2501007; e-mail: fxhodcsf@gmail.com).

II. Problem Formulation

Various techniques are used for image compression which includes discrete cosine transform, fractal compression, JPEG and discrete wavelet transform. Among these DCT, fractal compression is most commonly used technique. The discrete cosine transform (DCT) is a technique for converting a signal into elementary frequency components [3]. Fractal compression is a lossy compression and it requires more computational complexity. Thus the Image compression is involved by the Discrete Wavelet Transform for which the wavelets are discretely sampled. The algorithms have been implemented using visual C++. Here the Peak Signal to Noise Ratio is poor [2], [3].

III. Problem Solution

A. Quad Tree Decomposition

Most of the coding methods are based on image decomposition. Typically a natural image consists of several regions that possess local similarity and others that have extensively varying content. In this proposed scheme QTD is used. QTD is an image segmentation method that divides the image into homogeneous areas. There are various compression methods, the most popular being discrete cosine transform, fractal compression and discrete wavelet transform [5], [6]. The aforementioned methods are mathematically complex and time consuming. Thus to overcome the above mentioned problem QTD algorithm is used.QTD has a powerful compression potential. The QTD can be applied in two alternative approaches [8], Bottom-Up QTD and Top-Down QTD. The compression performed in this work is Top-Down QTD. The image compression performed in this work, is based on the Top–Down QTD method. In Top–Down decomposition, each image is initially divided into four blocks of equal size.

Next, each of the newly generated blocks recursively splits into four new blocks if it is in homogeneous and its size is greater than the minimum allowable block size [4], [7]. In general, in terms of processing speed, the Top–down QTD is considered to outperform Bottom–Up QTD for images which are either big or smooth while the latter performs better for images which have either small size or extensive textural features. In QTD every individual block is checked against a criterion of homogeneity. If this criterion is satisfied, the corresponding block is not divided any further. However, if the homogeneity criterion is not satisfied, the block is subdivided into four blocks. The process is executed iteratively until each block satisfies the homogeneity criterion is expressed as:

$$Max\,(MX\,4 - AVG\,4, AVG\,4 - MN\,4) \leq R\,/\,S(AVG\,(1 - y\,/\,2)\,/\,q) \quad (1)$$

In this formula, MX4 represents the maximum value of the four leaves of a branch, while MN4 expresses the minimum value found on this branch, and AVG 4 symbolizes the linear average of the values found on this specific branch, R is the decomposition factor, expressing the degree of compression, S refers to a scaling factor which corresponds to the size of the image region, represents gamma correction and q denotes the ratio of the region [10], [11].

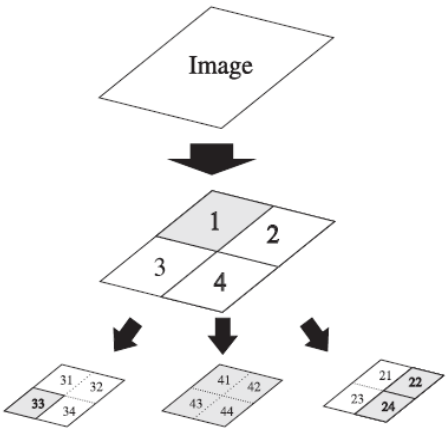

Fig. 1 QTD example in the form of a multilayer set of blocks and a corresponding tree structure

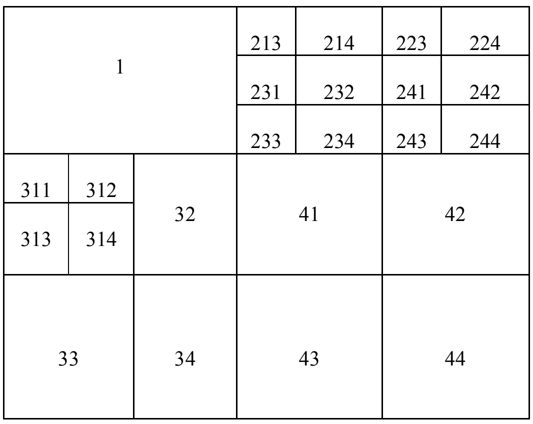

Fig. 2 QTD based on homogeneity criterion

B. Transmission Using Wireless Sensor Network

The Wireless sensor network consists of sensor nodes that are powered by small irreplaceable batteries. The data sensors sense motion, sound, heat or light to initially identify and locate the target. The decomposed image is converted into data packets then it will be transmitted to one node to another node using NS2 simulation. In the existing system does not analyze the difficulties in transmission line. Here the difficulty during transmission line is analyzed.

C. Steps Involve in QTD Algorithm

Step 1. Read the color image input, Resize the input image.

Step 2. Then decompose the image into quads based on homogeneity criteria.

Step 3. Convert the quads into data packets and the parameters such as PSNR, MSE, CR, BPP are analyzed

Step 4. Plot the graph for the above mentioned parameters.

Step 5. Transmit the packets through WSN and the parameters such as Delay, Transmission Time, Throughput, Packet Loss are to be analyzed.

Step 6. The data packet is received and the original image is reconstructed by decompression.

IV. Results and Discussion

In proposed system, the image captured from the camera is coded according to the QTD prior to transmission over the network. This then transmitted via WSN. The image sent over WSN is received at the receiver with some damaged or lost packets due to noise. The experimental setup is shown in the Fig. 3. The original image is given as an input to quad tree decomposition and gets converted into quadrants. Then the output is given as an input to compression which is used to align an image. The data packets are allowed to pass through wireless sensor network for transmission. In wireless sensor networks the data packets transmitted from source to destination using NS2 simulation. Then the output image is decompressed and quad tree composition is performed and reconstructed image is obtained.

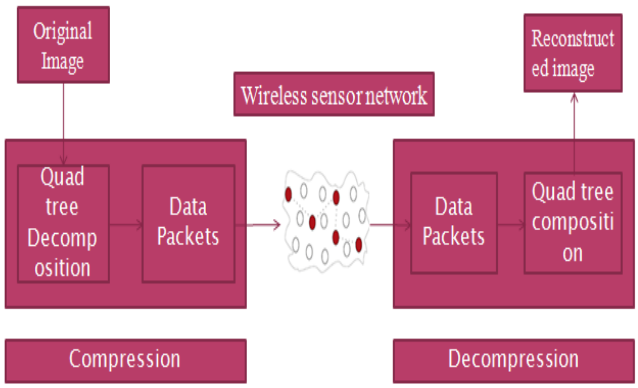

Fig. 3 Overall system architecture

A. Analysis of QTD Compression

The original image is given as an input to quad tree decomposition and gets converted into quadrants. Then the output is given as an input to compression which is used to align an image. The data packets are allowed to pass through wireless sensor network for transmission.

The original image of human iris is shown in Fig. 4 and then the image gets padded in Fig. 5. Here the image gets précised. The image gets decomposed using quad tree decomposition method. Then finally the image gets reconstructed by using quad tree composition. The effect of the decomposition factor R on the overall image size is depicted, while the same effect on the quality of the image, based on the Peak Signal to Noise Ratio (PSNR) Measurement is presented for different image sizes. Apart from this the proposed technique is also compared with other techniques.

Fig. 4 Original image of human iris

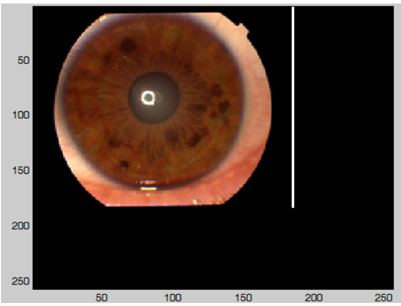

Fig. 5 Padded image of human iris

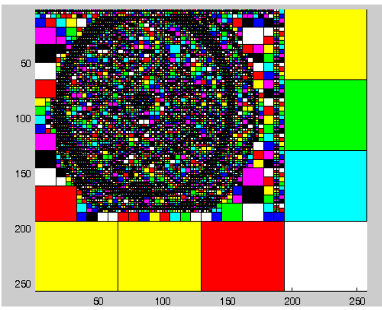

Fig. 6 Decomposed image of iris (Lossy Compression)

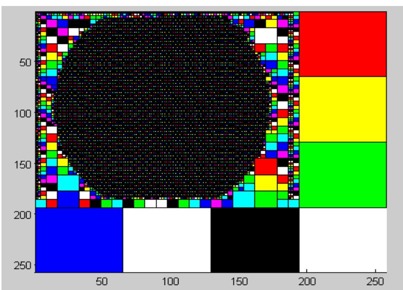

Fig. 7 Decomposed image of iris (Lossless Compression)

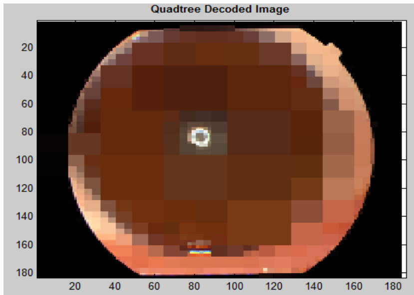

Fig. 8 QTD image of iris (Lossy)

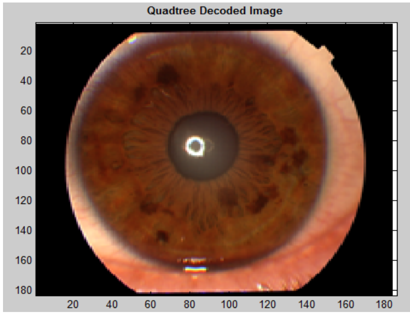

Fig. 9 QTD image of iris (Lossless)

In the proposed scheme, the lossy and lossless compression, both have been evaluated. For the lossy compression, the decomposed image of human iris is shown in Fig. 6, whereas for the lossless compression Fig. 7.

The decomposed image of human iris in lossy compression contain the various blocks of different intensities, but in lossless compression, the intensity near to black is highly present which shows that there is no loss of data, which is represented in Fig. 9.

B. Image Transmission Using WSN

The transmission of WSN have been performed in the following sequence: First, the aforementioned images of human iris at various resolutions with an 8-bit color depth have been decomposed to their Quad-Tree equivalent with various decomposition factors, varying from 0.1 to 0.9, subsequently the images have been transmitted over the network. The initial aim has been the measurement of the effect of QTD decomposition on the size of the transmitted compressed images and the corresponding transmission time needed, with respect to image size.

TABLE I
CONFIGURATION PARAMETERS FOR THE UTILIZED EXPERIMENTAL WSN

Network Characteristics	Values
Number of nodes	49
MAC sub-layer protocol	IEEE 802.15.4
Routing Protocol	Static
Data size per packet (Bytes)	234
Distance between nodes (cm)	5

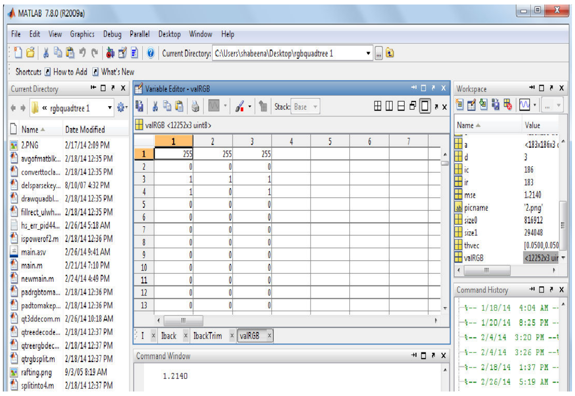

Fig. 10 Transmission Packet Format

The effectiveness of the compression can be evaluated by the parameters such as PSNR, Compression ratio, Mean Square Error, Bits Per Pixel. The graph is plotted for the above said compression parameters against various decomposition factors.

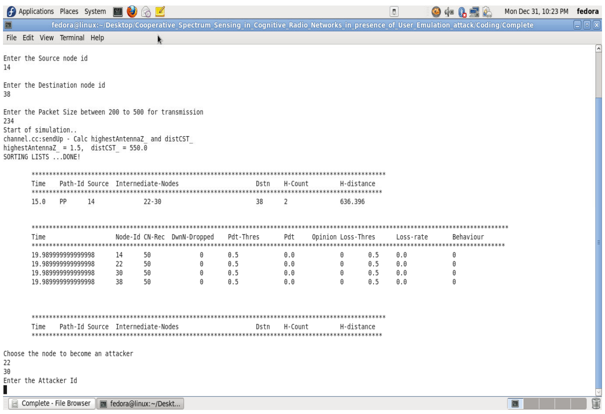

Fig. 11 Initialization of data packet

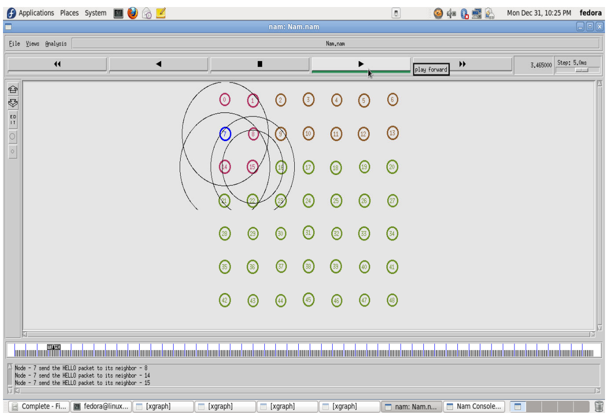

Fig. 12 Node discovery process

Thus the bits per pixel is defined by the number of bits of information stored per pixel of an image or displayed by a graphics adaptor. The more bits there these more colors can be represented, but the more memory is required to store or display the image. In the QTD, the value of the bits per pixel obtained for lossy compression is 1.4828 and for the lossless compression, the value of BPP is 18.0412. Fig. 11 shows the output window where the size of data packet is initialized. The data packet size is initialized in this window is 234. The attacker node is found out by initializing the node 22 and 30.

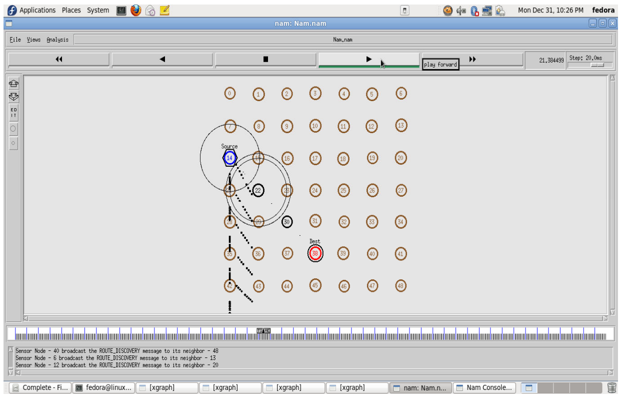

Fig. 13 Discovery of shortest path

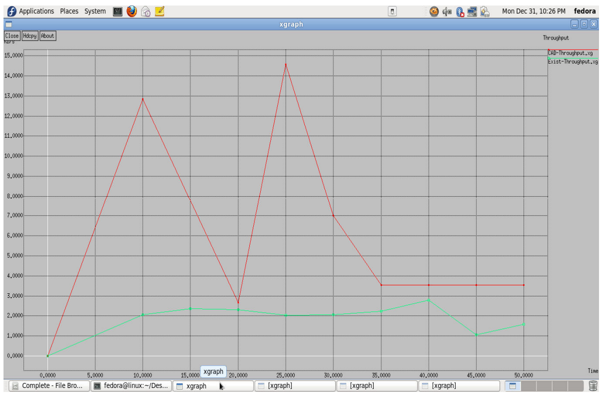

Fig. 14 Output Graph for Throughput

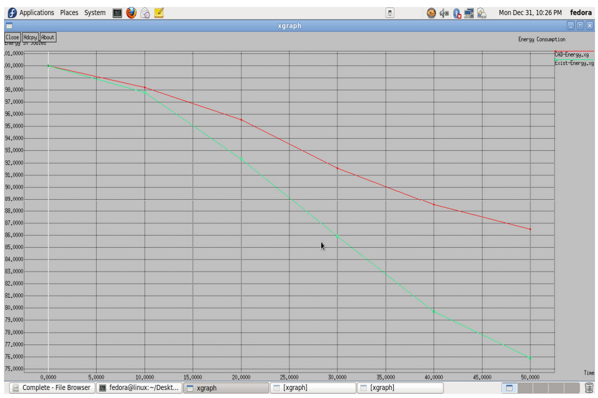

Fig. 15 Output Graph for Energy consumed

Fig. 12 indicates that the node discovery process is going on. The node which has blue color indicates the node discovery in the current node. Fig. 13 depicts that there is more than one shortest path is present. It broadcasts the route discovery message to the neighboring nodes. Fig. 14 shows the output graph for the Throughput. The output graph is plotted for the throughput during the packet transmission. The graph is plotted for the time vs. kilo bits per second. The time is taken in the X axis, while the Y axis having the Kbps. The Throughput graph shows the amount of data in bytes that received from the server in a second. When compare this with the transaction response time, it is noticed that as throughput decreased, the response time also decreased. Similarly, the peak throughput and highest response time would occur approximately at the same time.

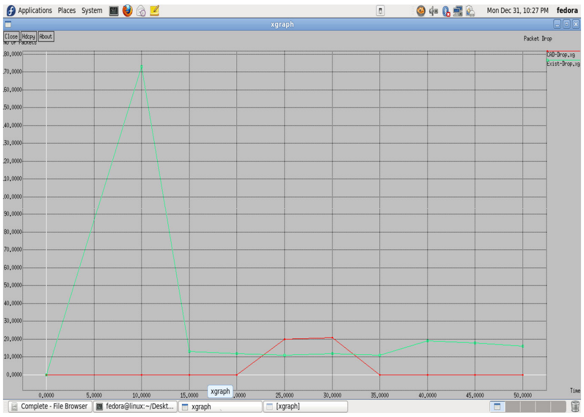

Fig. 16 Output Graph for Packet Drop

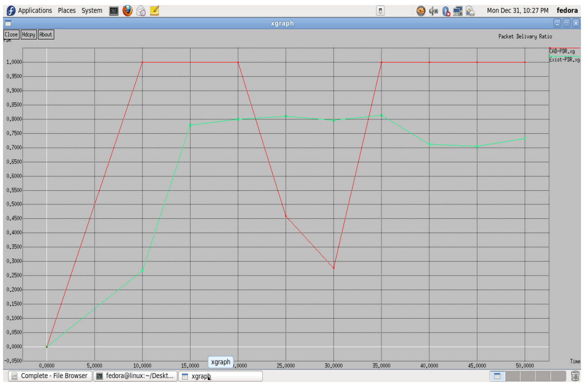

Fig. 17 Output Graph for Packet delivery ratio

Fig. 15 shows the output graph for the energy consumed. The output graph is plotted for the energy consumption during the packet transmission. The graph is plotted for the time vs. energy. The time is taken in the X axis, while the Y axis having the energy in joules. The energy consumption in packet transmission is defined as the ratio of total amount data delivered and total energy consumed for the current node. Here, the problem of minimizing the energy used by a node on point-to-point link to transmit packetized information within a given amount of time. To minimize transmission energy, the proposed method vary packet transmission times and power levels to find the optimal schedule for transmitting the packets within the given amount of time. Fig. 16 shows the output graph for the packet drop. The output graph is plotted for the packet drop during the packet transmission. The graph is plotted for the time vs. number of packets. The time is taken in the X axis, while the Y axis having the number of packets. Packet loss occurs when one or more packets of data travelling across a computer network fail to reach their destination. The lower value of the packet lost means better performance of the protocol.

Packet lost = Number of packet send – Number of packet received

Fig. 17 shows the output graph for the packet delivery ratio. The output graph is plotted for the packet drop during the packet transmission. The graph is plotted for the time vs. number of packets. The time is taken in the X axis, while the Y axis having the number of packets. Packet Delivery Ratio (PDR) is defined as the ratio of the number of delivered data packet to the destination. This illustrates the level of delivered data to the destination. The greater value of packet delivery ratio means the better performance of the protocol.

PDR = ∑ Number of packet receive / ∑ Number of packet send

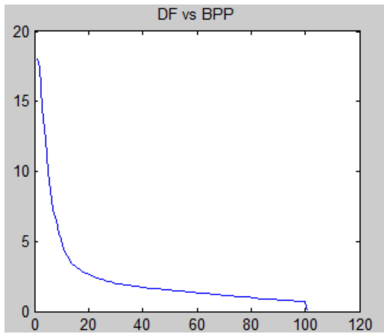

Fig. 18 DF vs. BPP (Lossy Compression)

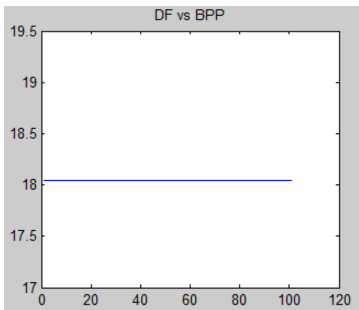

Fig. 19 DF vs. BPP (Lossless Compression)

The second parameter to be analyzed is Mean square error, and it is defined as the difference between estimated and the true value of the quantity being estimated. The MSE measures the average of the square of the “error”, with the error being the amount by which the estimated differs from the quantity to be estimated.

In the QTD, the value of the Mean Square Error obtained for lossy compression is 30.1070 and for the lossless compression, the value is 0.

The third parameter to be analyzed is compression ratio and is defined by the ratio of uncompressed image size to the compressed image size, the compression ratio that to be obtained for lossy compression is 16.1854 and for the lossless compression is 1.3303.

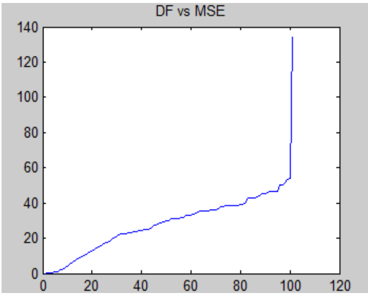

Fig. 20 DF vs. MSE (Lossy Compression)

The fourth parameter is Peak signal to noise ratio, and is defined by the ratio between the maximum possible power of a signal and the power of corrupting noise.

Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale. The PSNR obtained through QTD is 33.3441 for lossy compression and infinity for the lossless compression.

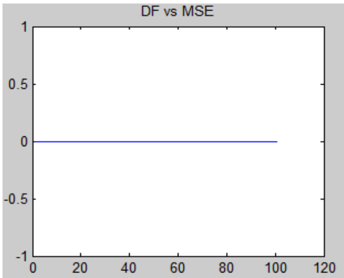

Fig. 21 DF vs. MSE (Lossless Compression)

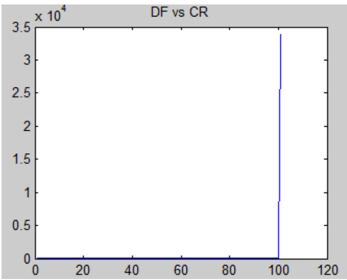

Fig. 22 DF vs. CR (Lossy Compression)

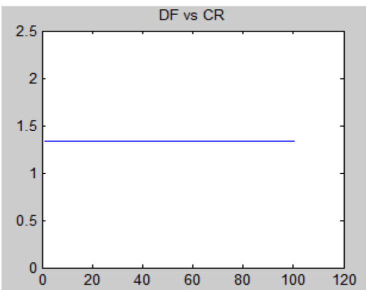

Fig. 23 DF vs. CR (Lossless Compression)

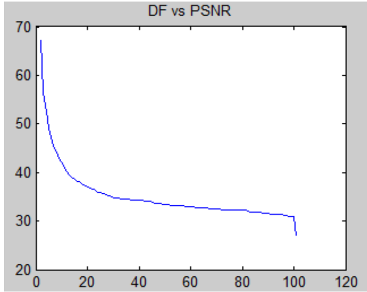

Fig. 24 DF vs. PSNR (Lossy)

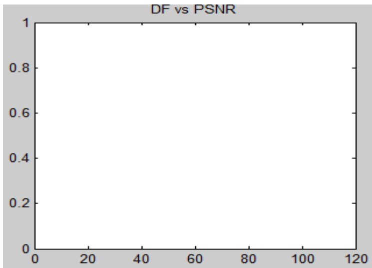

Fig. 25 DF vs. PSNR (Lossless)

TABLE II
COMPARISON BETWEEN LOSSY AND LOSSLESS COMPRESSION IN QTD

Parameters	Lossy Compression	Lossless Compression
Peak Signal to Noise Ratio	33.3441	INFINITY
Mean Square Error	30.1070	0
Compression Ratio	16.1854	1.3303
Bits Per Pixel	1.4828	18.0412

TABLE III
COMPARISON OF VARIOUS PARAMETERS IN WSN

Parameters	Existing Method	Proposed Method
Throughput	2.8 bytes/sec	14.8bytes/sec
Energy consumption	76%	86.3%
Packet drop	72%	20%
Packet Delivery Ratio	71-81%	30-98%

V. CONCLUSION

In this Research analysis compression and restoration of sequentially transmitted images over Wireless Sensor Networks (WSNs) has been presented. The proposed method is based on Quad tree decomposition for image compression. QTD compresses the volume of the image data to be transmitted by clustering the image in sets of variable size and of similar type of color information. Image in painting is used for fast restoration of missing data packets by reconstructing its damaged or missing portions from surrounding information. Thus the overall proposed scheme has been applied to multiple experimental studies that prove the efficacy of the proposed algorithm.

ACKNOWLEDGMENT

This work was supported in part by Anna University recognized research center lab at Francis Xavier Engineering College, Tirunelveli, India. We extend our gratitude to Dr. R. Ravi for his support and guidance. Also, we would like to thank the anonymous reviewers for their valuable comments and suggestions.

REFERENCES

[1] G. Nikolakopoulos, P. Stavrou, A. Tzes, D. Tsitsipis, D. Kandris, T. Theocharis, "A dual scheme for compression and restoration of sequentially transmitted images over Wireless sensor networks", Elsevier Journal, Vol. 1, Issue1, January 2013, pp- 410-426.
[2] M. Mozammel Hoque, Amina, Khatun, "Image Compression using Discrete Wavelet Transform", International Journal of Computer Science Issues (IJCSI), Vol. 9, No.1, Jul 2012, pp.621-627.
[3] Maneesha Gupta, Dr. Amit Kumar Jarg, "Analysis of image compression using Discrete Cosine Transform", International Journal Engineering Research Applications (IJERA), Vol. 2, No.1, Jan-Feb 2012, pp. 515- 521.
[4] Y. Wexler, E. Shechtman, M. Irani, "Space-time video completion", IEEE Transactions on Pattern Analysis and Machine Intelligence, Volume 29, No.3, 2007, pp 463–476.
[5] W. Tan, A. Zakhor, "Real-time Internet video using error resilient scalable compression and TCP friendly transport protocol", IEEE Trans Multimedia, Vol. 1, Issue2, June 1999, p.p. 172- 186.
[6] J. De Bonet, "Multi resolution Sampling Procedure for Analysis and Synthesis of Texture Images", In Computer Graphics (SIGGRAPH'97 Conference, Proceeding), Aug 1997, pp- 361- 368.
[7] J. Vaisey, A. Gersho, "Image compression with variable block size segmentation", IEEE Transaction on Signal processing, Vol. 40, p.p. 2040- 2060, Aug 1992.
[8] G. J. Sullivan, R. L. Baker, "Rate–distortion optimization for tree structured source coding with multi- way node decisions", in Proc, IEEE Int.Conf.Acoust. Speech Signal Processing (ICASSP), pp III- 393- 396, Mar 1992.
[9] G. J. Sullivan, "Low-rate coding of moving images using motion compensation, vector quantization and quad tree decomposition" Ph.D. thesis, Univ.of Calif., Los Angles, Sept- 1991.
[10] P. A. Chou, T. Lookabaugh, R. M. Gray, "Optimal pruning with applications to tree- structured source coding and modeling", IEEE Trans.Inform.Theory, Vol. 35, p.p. 299-315, Mar1989.
[11] A. Wyner, J. Ziv, "The rate-distortion function for source coding with side information at the decoder", IEEE Trans. Inform. Theory 22(1), Jan 1976, pp. 1-10.

Muthukumaran. N was born in Kaniyakumari, Tamilnadu, India, in 1984. He received the B.E (ECE) from Anna University, Chennai, India, in 2007 and the M.E (Applied Electronics) from Anna University, Chennai, India, in 2010. Where he is currently working toward the PhD (Information and Communication Engineering) Degree, Anna University, Chennai, India. He is currently working as an Assistant Professor & Research center lab in Francis Xavier Engineering College, Tirunelveli. His major research interests are Image Processing/ Compression, Digital and Analog Very Large-Scale Integration circuit design. He conducted several projects in the area of Image processing, Image Compression, Very Large-Scale Integration circuit. Since 2008 he has published more than 9 journals in International and 26 National/International conferences papers.

Dr. R. Ravi is an Editor in International Journal of Security and its Applications (South Korea). He is presently working as a Professor and Head of the Department of CSE, Francis Xavier Engineering College, Tirunelveli. He completed his B.E in Computer Science and Engineering from Thiagarajar College of engineering, Madurai in 1994 and M.E in CSE from Jadavpur Government research University, Kolkatta. He has completed his PhD in Networks from Anna University Chennai. He has 18 years of experience. He is the first person in India from a private institution who was the judge (Chair person) for an International conference in IIT, Chennai. He published 20 International/National Journals, and 4 international Journals are under process. He actively participated in 15 international Conference, 80 National Conferences and bagged shields in many. He is also a full time recognized guide for various Universities. Currently he is guiding 9 research scholars. His areas of interest are Virtual Private networks, Image Processing.