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Energy Efficient Cooperative Image Transmission in Multi-Hop Wireless Multi-Media Sensor Networks

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Abstract: The world has taken a drastic look towards scalar mobile wireless multi media sensor networks (MWMSN) and almost all the nodes (IOT devices) are connected via the internet. The amount of image, video and data transmission has increased significantly. For battery-powered smart gadgets like smartphones and tablets, energy efficiency is a constant issue. To fully utilise the advantages of the multiple-input-multiple-output technology, MWMSN heavily relies on cooperative communication. Since each node in a cooperative mobile multimedia sensor network is mobile, energy consumption and routing present significant issues. Since each node in the network is mobile, energy consumption and routing pose significant problems for cooperative mobile multimedia sensor networks. To address these challenges optimal cooperative relay selection (OCRS) technique was proposed by utilizing velocity, distance, and connection quality factors. The suggested method bases its determination of the link quality for each pair of nodes on the signal strength and distance values. The highest quality of service (QoS) rating, which is determined to ensure route stability, reliability, and durability, is chosen as the relay nodes. Further, we have proposed an energy efficient cooperative multi media transmission (EECMT) to achieve a better compression rate with lower energy consumption. This approach utilizes the auto-correction code feature present in the QR code to further improve the performance of MWMSN. The simulation result shows that the proposed approach gives better performance and saves the energy up to 39% (approximately) compared to the efficient cooperative image transmission (ECIT), energy efficient relay node placement (EERP) and energy aware cooperative image transmission (EACIT) approaches.

Keywords: 2D-discrete wavelet transforms, Wireless multimedia sensor networks, Decode and forward, Cooperative image transmission, Energy efficiency, Relay selection.

1. Introduction

The term "wireless multimedia sensor networks" (WMSN) refers to a specific class of wireless sensor networks (WSN) that may transmit multimedia data, such as audio and video streams [1]. Smart, compact, and reliable sensors are employed in WMSNs. Sensor nodes (SNs) with resource constraints dispersed across a wide area.

The globe is seeing an increase in the usage of wireless sensor networks, mostly because they are less expensive to construct and operate. Additionally, because wireless sensor networks are more flexible, it is simpler to modify sensor systems to user demands, connect to the internet, and function as an IOT device [2]. We can get data about our immediate surroundings using wireless sensors with minimum manpower. In the present world, wirelessly connected devices are ubiquitous. The key benefit of wireless sensors is that they may enable IoT applications and need no maintenance [3].

Cooperative communication (CC) [4] enables network communication endpoints to acquire and transfer data. In cooperative wireless multimedia communications, we are concerned with a wireless, cellular, or commercial network in which wireless agents, or users, can cooperate to improve the service quality level. By utilizing wireless multimedia communication transmission, we can make the exchange of information between parties easier. Every wireless user is regarded to send multimedia information and serve as an intermediary for other users helping in boosting the spectrum power and effectiveness, increasing network connection, and boosting communication dependability. Additionally, cooperative communication has better hardware performance and flexibility when compared to other cutting-edge techniques that can provide the same performance improvements, including the multiple-input multiple-output (MIMO) technology [5].

Although these all advantages help the network to grow, a few important challenges are also faced during data transmission over WMSN [6], these large data may require a lot of time for transmission, on the other hand, if the data is huge, the high energy consumption during transmission, large storage space and lag in the transmission is found. One of the solutions to overcome this is small data transmission [7], but as technology grows, the way and the lifestyle of living are also changed and data is growing larger and larger. Despite all these circumstances, Multimedia transmission in sensor networks requires more node batteries than other WSN applications. The outcome is a decrease in network longevity due to the high volume of data [8] for wireless broadcasts across sensor networks.

In order to address these problems by lengthening the network lifespan, better image compression and transmission, we proposed a coherent energy cooperative multi-media transmission (EECMT). The proposed approach is divided into two stages.

- In stage 1, develop and implement a novel optimal cooperative relay selection (OCRS) approach based on distance, mobility and link quality for MWMSN.
- In stage 2, to improve the energy efficiency, energy efficient cooperative multimedia transmission (EECMT) approach is presented.

The rest of the paper is organized as follows. In section 2, we presented the related work. Our model, relay selection approach and energy efficient cooperative multi-media transmission (EECMT) are presented in section 3. Consumed energy and time taken for transmission calculations are presented in section 4 respectively. Section 5 gives the simulation results of proposed approach and finally we concluded our paper in section 6.

2. Related work

People have chosen various interests in multimedia transmission across multi-hop wireless networks, and various researches have been carried out to enhance network performance. A few of them were found to be helpful for consideration A framework for quality-aware and energy-efficient multi-hop one-way cooperative image transmission was proposed by authors in [9] that used a method of picture preparation, wavelet-based two-dimensional discrete wave-let transform (2D-DWT) method, the decode-and-forward (DF) technique at relays. As described in [10] an image sensor transmission plot focused on the community might be made by combining sensor linkages with grab, sharing-security instances. The mechanism was recommended to disperse mysterious images in multiple Centre areas.

In [11] the authors proposed designation collaboration for increased picture transmission quality while drastically reducing energy usage for image applications in WMSNs. It also examines these unique importance levels in picture data streams. System resources were properly divided between the PHY, Macintosh, and application levels to ensure component dependability while enhancing the quality of the image transmission. The research's conclusions indicate that the suggested technique is sufficient for generating the finest image quality and efficacy in terms of vitality.

To produce energy-efficient image transmissions in WSNs, in [12] collaborative signal improvement method was used. Because it may reduce individual energy use by distributing absolute transmission usage across several sensors, a community signal upgrading strategy proved convincing. An essentially in-consistent commitment to image quality can be seen in singular parcels representing an implanted wavelet-encoded image. Based on this reality, they came up with a plan to choose the ideal number of neighborhood-focused sensors for each parcel transmission to obtain the highest image quality possible de-spite having a limited budget for transmission energy use. For efficient energy transmission of image over WSN a novel architecture and protocol was presented in [13]. The authors' method makes use of SDF participation, allowing a handoff center to collaborate with the source by delivering only a little amount of data.

A collectively new idea was put out in [14] by the author: a proximity WMSN model and image transmission strategy. The arrangement that was suggested was evaluated based on the reproduction of the image with PSNR and incentre imperativeness use. With an acquired image PSNR of 46 dB, the pro-posed technology saved 95% of the Centre point importance when compared to another avant-garde strategy.

According to [15, 16] reference earlier studies on image and data transfer methods for WSNs. However, there are still a few issues that need to be re-solved when managing brilliant picture transmissions cooperatively in WSNs, such as excessive energy consumption while planning steps to produce the broadcast bordered by visual excellence and generosity of transmission, and use of picture transmission. Numerous techniques are used by the systems under examination to demonstrate their appropriateness.

In [17], a fresh idea for picture transmission was put out using two distinct viewpoints on WSN power efficiency. Both an open-loop approach and a closed-loop method were devised. These techniques were created using wave-let picture alteration and trustworthy transformation to save energy. Information about the wavelet image modification characteristics is broken down into several levels of resolution. In order for the picture to travel via collaborative communications, it must be split into packets.

A cooperative conversion strategy for sequentially converting photo sensors employing intra-sensor communication for model change and distribution security was proposed in [18]. The author gave a wonderful presentation on energy capacity and secure picture transfer. This tactic did not allow for the transmission of all pictures by the sensor when paired with an active trans-form to ensure that the tracks were powered appropriately. It also did not offer all aligned image regions with the ability to save money when combined with track preferences and BER was needed. For wireless sensor networks, the author in [19] offers an improved LEACH method. The system, which makes use of fuzzy inference techniques, prolongs the network lifetime while simultaneously lowering packet loss. According to the literature, hierarchical approaches based on a clustering hierarchy are available to save energy in WSNs. The nodes with the most energy left in this scenario may be utilized to gather data and transmit it to a base station. The effectiveness of this strategy is demonstrated by simulation results.

The authors of [9, 20-22] described a successful image transmission strategy that depends on reflected picture transmission over wireless channels to achieve the greatest image quality and bit error rate performance. In [9], First a lightweight image quality improvement mechanism was built at both the transmitter and receiver ends while pictures were taken under various lighting conditions. Second, the approximation coefficient of the 2 D discrete wavelet transform was used to execute the recommended compression technique, by employing decode and forward (DF) relaying protocol. The hybrid thresholding function was created; lastly, incoming visual data using the decode-forward approach at relay nodes, blocks are decrypted and trans-mitted. Following the conventional orthogonal frequency division multiplexing model, the inverse fast Fourier transform is applied using the compressed approximation component of the 2-D discrete Wavelet transform, and is then modulated using quadrature phase shift keying to transmit over an additive white Gaussian noise channel to relay nodes. In [21], to achieve the desired bit error rate, the source node acquires the maximum power needed to transmit the image. Spatial multiplexing is then applied, significantly enhancing the functionality of the MRMH-WSN. In [29], authors have been proposed a plan for the relay nodes energy efficiency based on four popular indoor heterogeneous network topologies. Based on a comparison of the relay nodes linkages and distance, the algorithm with the least amount of energy consumption is offered. The findings demonstrate that the circular network architecture is the best network model, with a 6% gain in efficiency.

In this paper an energy efficient cooperative multimedia transmission (EECMT) approach is presented to improve energy efficiency. To achieve this, a novel optimal cooperative relay selection (OCRS) approach based on distance, mobility, and link quality for MWMSN is presented. This approach selects the optimal relay node with high link quality. Further, to improve energy efficiency, energy efficient cooperative multimedia transmission (EECMT) approach is presented. In this, the image is encoded into QR form and applied the compression techniques, and then transmitted over multi-hop wireless networks. The notations used in this paper are listed in Table 1.

3. System model

We considered a cooperative multimedia multi-hop wireless sensor network, where N nodes are randomly distributed over an area of $L * B\, m^2$.

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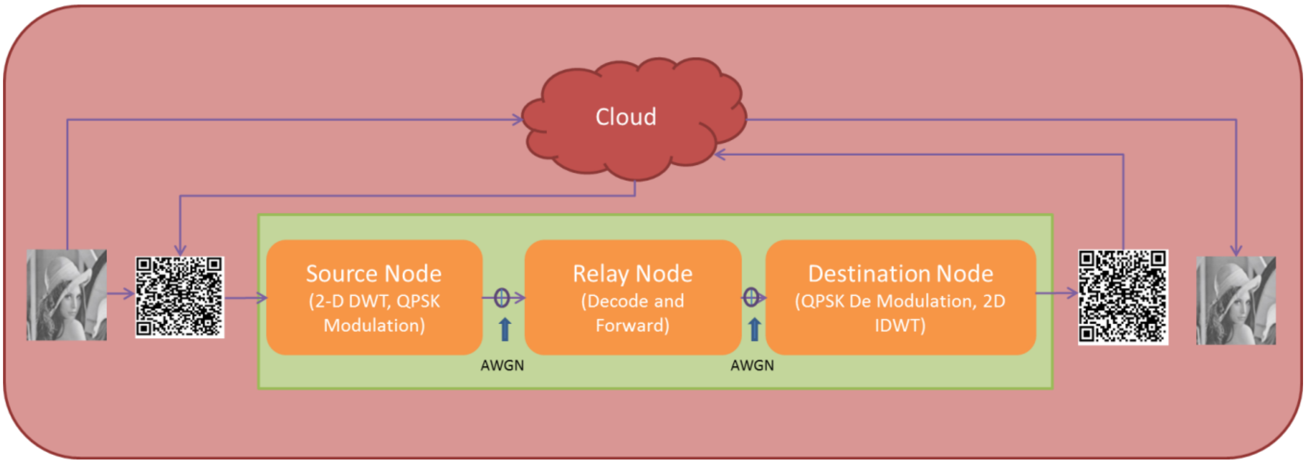

Figure. 1 Flow diagram

Table 1. Summary of notations

Symbol	Description
N	Number of nodes
M_s	Source node
d_{M_s,M_l}	distance between M_s and M_l
$N(M_s)$	transmission coverage area of source node
$LQ(M_s)$	Link quality
C_{M_s,M_l}	available capacity between M_s and M_l
WF_{M_s,M_l}	Weight factor
MF	Mobility factor
S_{AF}	Amplification factor
$H_{l,j}$	Rayleigh channel fading coefficient
n_i	AWGN noises with zero mean
T_V	Symbol period
α	transmission efficiency
d_{ij}	distance between the node i and j
G_{Tx} and G_{Rx}	Gain factors of transmitter and receiver
M_l	Link margin
N_f	noise figure

Where L is the length and B being the breadth. Every node in the network is assumed to be self-organized randomly at different positions and employs the decode and forward (DF) relay protocol. Fig. 1 explains the proposed system and the flow of the process. The efficient usage of cloud, the QR encoding from image and image compression algorithm applied to encoded image. The first step involves the small pre-processing of an image to convert the image into a QR code. This conversion process doesn't require the direct conversion of the image to a QR code but an intermediate significant task is being done i.e., the image is first uploaded to the cloud. As the cloud allocates some amount of data to the image and a link is provided to access the image.

3.1 Relay selection

For mobile wireless multimedia sensor networks, the optimal cooperative relay selection (OCRS) method is discussed in this section. By taking capacity, connection quality, distance, and mobility parameters into account, this routing technique enhances the scalability of optimized link state routing (OLSR). Let the source node be M_s and the two-hop node be M_l. The metric values are assigned to the link between $(M_s; M_l)$; d_{M_s,M_l} is the distance between M_s and M_l, and WF_{M_s,M_l} be the weighting factor between M_s and M_l. The available capacity between M_s and M_l is denoted by C_{M_s,M_l}. The link quality for M_s is $LQ(M_s)$, and the set node under the transmission coverage area of source node is $N(M_s)$.

$WF_{M_s,M_l}$is inversely proportional to the mobility factor and proportional to the distance. The ratio of the CR of M_l to the total CR is the proportionality constant. It is possible to provide WF_{M_s,M_l} as demonstrated in the equation below:

$$WF_{M_s,M_l} = \left(\frac{CR_{M_l}}{CR_{M_s}+CR_{M_l}}\right) \times \left(\frac{d_{M_s,M_l}}{MF}\right) \qquad (1)$$

The source node will compute WF_{M_s,M_l} using periodic beacon signals and the distance between two nodes as indicated by Eq. (2) provided by [59].

$$d_{M_s,M_l} = \lambda\left(\frac{\phi}{4\pi} - \frac{B}{2}\right) \qquad (2)$$

Where the carrier's wavelength is λ. B is an integer, and ϕ is a complete phase obtained from signals transmitted using a constant carrier frequency.

Low-speed moving nodes are ideal for CR nodes in the proposed approach since they can rebroadcast

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the information. The mobility factor average value, which depends on the speed of one's own node, is shown in Eq. (3). In this equation, the computation of the next hop is done first.

$$MF_{M_s,M_l} = \frac{V_l - V_{min}}{V_{max} - V_{min}} \quad (3)$$

Where V_l depicts the speed of the relay node. V_{max} and V_{min} are the maximum and minimum speeds of the node, respectively.

The route link quality can be obtained by taking the product between weighting factor $\left(WF_{M_s,M_l}\right)$ and capacity as shown in Eq. (4). If the mobility factor MF_{M_s,M_l} is small, the WF_{M_s,M_l} produced by Eq. 4 is large, resulting in a larger LQ_{M_s,M_l}.

$$LQ_{M_s,M_l} = LQ_{M_s,M_l} \times WF_{M_s,M_l} \quad (4)$$

According to LQ_{M_s,M_l} parameter, our method chooses the source node's CR set; the algorithm chooses the node M_l with the greatest LQ_{M_s,M_l}. The source node is assisted by other nodes in the set in forwarding information to the cluster head also known as the Candidate relay node.

3.2 Cooperative image transmission

In the method of energy efficient cooperative multi-media transmission (EECMT), the coherent energy refers to the effective energy consumption at intermediate nodes and increasing the network lifetime with the help of the auto-error correction feature of the QR code.

As any generated link is small in size rather compared to the size of the image, this link is further converted towards the QR code. The QR symbol that is generated contained the link of the image and is completely independent of the original image thus any changes by noise during the image transmission may affect the QR code but there shall not be any degradation to the original image to be transmitted.

3.2.1. Pre-processing

Any image to be transmitted is first stored on the internet and a quick response code is generated. A quick response (QR) code is an improvised version of a barcode that evolved in mid-1994. In general, this code appears in small regular square boxes and stores encoded data. It can also be considered virtual data storage medium on physical objects through rapid mobile web services. The algorithm 1 gives the detail description of pre-processing.

When a QR code is scanned, the user gets immediate access to the encoded content present in it, the encoded content such as URL or any such similar data triggers an action and targets the user's web browser or connecting to a wireless network. Usually, American standard code for information interchange (ASCII) text or binary code is stored as content kept encoded in it.

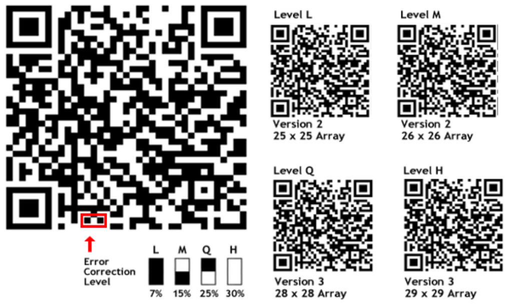

Figure. 2 Error correction levels in QR code

As QR code is well known for its quick usability, it is also more static in terms of storing content in it. It is also readable even if the code is found to be blurred, partially damaged or obscured. We see many cases where even if the code was not properly visible but mobile phones can get access to it on a single scan. This is achieved with the error correction keys present in every small single black square box of the QR code. Various levels of QR codes classified based on their error correction capability are:

1. This level is the lowest - "L" for error correction. Mostly all the QR code generators use this level to avoid code damage in further steps. Here in this level, the maximum threshold for error correction available is just up to 7%.
2. Level M – up to 15% error correction. This level is called level-M middle tire error correction level, here in this error correction, the QR code is damaged up to 15% of its original value. As the error correction keys are capable of auto re-correct this error is mostly negligible.
3. Level Q – up to 25% error correction: This is the second highest to the maximum error correction. Here the image is maximumly damaged by up to 25% and can be recovered.
4. Level H – up to 30% error correction: This is the highest to the maximum error correction. Here the image is maximumly damaged by up to 30% and due to this huge error presence; the code sometimes cannot be recovered.

Based on [23] it is found that the code is highly readable with up-to 25% of damage and can withstand to provide the actual content present in it

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Algorithm 1. Preprocessing

Preprocessing
I = Image Captured by T, Inputs, Cloud storage, Get the URL, Generate QR code, input=Quality(I)

Algorithm 2. Transmitter

Transmitter
Inputs. Rn = R1, R2 … Ri (R Nodes), , T = T Node, I = Picture Captured by T, Wname = 'HAAR wavelet', 1. Get current frame I, 2. P = Quality (I), 3. [cA,cH,cV,cD] = 2D_DWT (P, Wname), 4. Implement QPSK, cAm = mod (cA, QPSK), 5. D = {cA, cH, cV, cD} 6. Get the packetize {I1, I2, I3, I4} , 7. Send blocks by AWGN-- (AWGN {I1, I2, I3, I4}),

over 25%. These various levels are also described in [24].

We generally have various kinds of data and the image is one of them. Primarily as a part of the preprocessing, the image to be transmitted is first uploaded into the cloud (Internet) and generates a link to access it. These generated links are quite long and arduous to remember so here comes the picture of the QR code.

3.2.2. Discrete wavelet transform and modulation

The 2D-discrete wavelet transforms (DWT) provide the best way for image composition and decompression. This compression can be obtained by sub-sampling and filtering methods, this process very effectively reveals data redundancy and performs the image compression without huge losses. This discrete wavelet transform was found superior to Fourier and discrete Cosine transform. In discrete wavelet transform (DWT) the main advantage is it provides all the details of coefficients such as approximation, horizontal, vertical and diagonal respectively.

This QR code obtained is moved for the further steps of data compression through the bidirectional discrete wavelet transform and then for easy transmission and considering the sensor network drifts, it is modulated with the help of quadrature phase shift keying. This entire process takes place in

Algorithm 3. Relay node

Relay nodes

At nodes
If(detected):
    QPSK demodulation
Else:
    Pass
    (Do nothing)
 	
Modulation (QPSK)
send blocks by AWGN and Packetize

Algorithm 4. Destination

Destination
Ir—Received picture 1 = demod (Ir {1}, QPSK), 2. R = IDWT (I1, I2, I3, I4), 3. Fr = Quality (R), 4. quality comparison(P,Fr), 5. out=QR code decoded image, 6. Quality comparison(out, input);

the source node, this compressed and modulated image QR code is ready for transmission over the relay nodes present in the sensor network.

This QR code with noise is even capable of retrieving the actual image from the cloud because of the special feature of self-error correction capability present by built-in the QR code. With the help of this error correction capability, it can correct the corrupt part of the image and works as the source code.

In the sensor network, the destination node retrieves the data of the QR code while the relay nodes just decode and forward the data as that comes to them. At the destination, the demodulation of the data takes place with quadrature phase shift keying and upon applying the inverse discrete wavelet transform; the final QR demodulation is obtained.

3.2.3. Demodulation

At the destination, various IoT nodes are capable the scan the QR code on their own, even though if the code is not in proper form i.e., with a good amount of noise, the actual image can be obtained without any ease, the data transmission has reduced which results in the reduction of power consumption and same image which is transmitted on the other side is received with the best satisfaction.

4. Evaluation of energy consumption

In general, wireless multimedia sensor networks are more concerned with the amount of energy the nodes consume because the WSN nodes are kept isolated with some battery and are not charged or changed for a long time. The logic and associated computational activities may be properly divided by introducing the idea of cooperation. Energy consumption is considered to be the secondary comparison parameter throughout this project, whereas the image quality comparison is the primary parameter during simulation. The energy consumed amount per bit $i\ to\ j$ in the transmission is given by E_h (Eq. (5)) in [25-27].

$$E_h = \sum_{i=1}^{H} (1+\alpha)(P_t/K)Q\left(d_{ij}\right)^n M_l N_f + \frac{P_{Tx}+P_{Rx}}{b} \quad (5)$$

Where $Q = \frac{(4\pi)^n}{G_{Tx}G_{Rx}\lambda^2}$, b *is* bitrate, $\alpha = \left(\frac{\zeta}{\xi}-1\right)$, is the transmission efficiency of the power amplifier. To minimize energy consumption, we have suggested an efficient-energy transmission scheme namely coherent energy cooperative multi-media transmission where the transmission power of a node can be minimized to meet the bit error rate, P_b target. The maximum transmitting power P given by Eq. (6).

For QPSK, 4 points which are equiprobable are spaced at a distance of $\sqrt{2E_b}$ from origin each, that is they are placed on vertices of a square of side $2\sqrt{E_b}$. So, for QPSK,

$$P = 2\frac{4(E_b)}{4} = 2E_b. \quad (6)$$

Here E_b is the energy per bit and P is the power which is assumed as proportional to the distance of the signal point from the origin in the constellation. the probability of bit-error for QPSK is $P_b = Q\left(\sqrt{\frac{2E_b}{N_0}}\right)$.

5. Simulation results

In this section, we present the simulation results of proposed approach and compared with state-of-art algorithms. MATLAB software was used to run the simulation and the simulation parameters like $1000\ X\ 1000\ m^2\ area,$ with 30 nodes placed randomly with a meer distance of 200m apart. The suggested methodology is used on five distinct photos to compare. The image quality parameters like MSE, SSIM, and PSNR [28] are taken for comparison.

5.1 Mean square error

To evaluate the quality of the images obtained at the output to the input, a few evaluation matrices are used such as mean squared error (MSE), structural similarity (SSIM) index and peak sigal to noise ratio. The MSE describes the mean square mistakes obtained between the destination node-D to that of the source node-S, it is calculated by Eq. (7) as:

$$MSE = \frac{\sum_{MN}\left(I_1(m,n)-I_2(m,n)\right)^2}{M*N} \quad (7)$$

where m and n indicate the pixel coordinates.

5.2 Structural similarity (SSIM) index

The structural similarity (SSIM) index defines how similar to the obtained image at the destination that of the transmitted image. In general, the SSIM value ranges from 0 to 1. Here if the value is 1, it describes the output as the same as the input. Here the image comparisons are on the bases of 3 main features structure, contrast and luminance.

5.3 Peak signal to noise ratio

This is one other parametric analysis which calculates the ratio of signal power to Noise power by comparing both images similar to those above. The PSNR of an image with the intensity L is calculated by Eq. (8) as:

$$\mathrm{PSNR} = 10\log_{10}\left(\frac{\mathrm{L}^2}{\mathrm{MSE}}\right) \quad (8)$$

The performance of proposed approach is verified for sixty-five images from digital image processing (DIP) images, twenty MATLAB images and eighty-five images from COVID-19 radiography database. Some of the images from these datasets are presented in Table 2.

As the QR image passes through the network and gets corrupted with the noise. As a result, the size of the obtained image at the reception is slightly larger than that of the transmitter side. As this model is built to achieve the primary goals of Higher quality image reception, less energy for transmission and less propagation time, these are achieved by observing the high-quality image obtained at the receiver.

The Table 3 describes the quality of the received QR code concerning PSNR this clearly shows that even with the average PSNR of 50.57 dB can extract

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Table 2. Input image, image QR code, compressed QR code, QR at receiver, image at destination

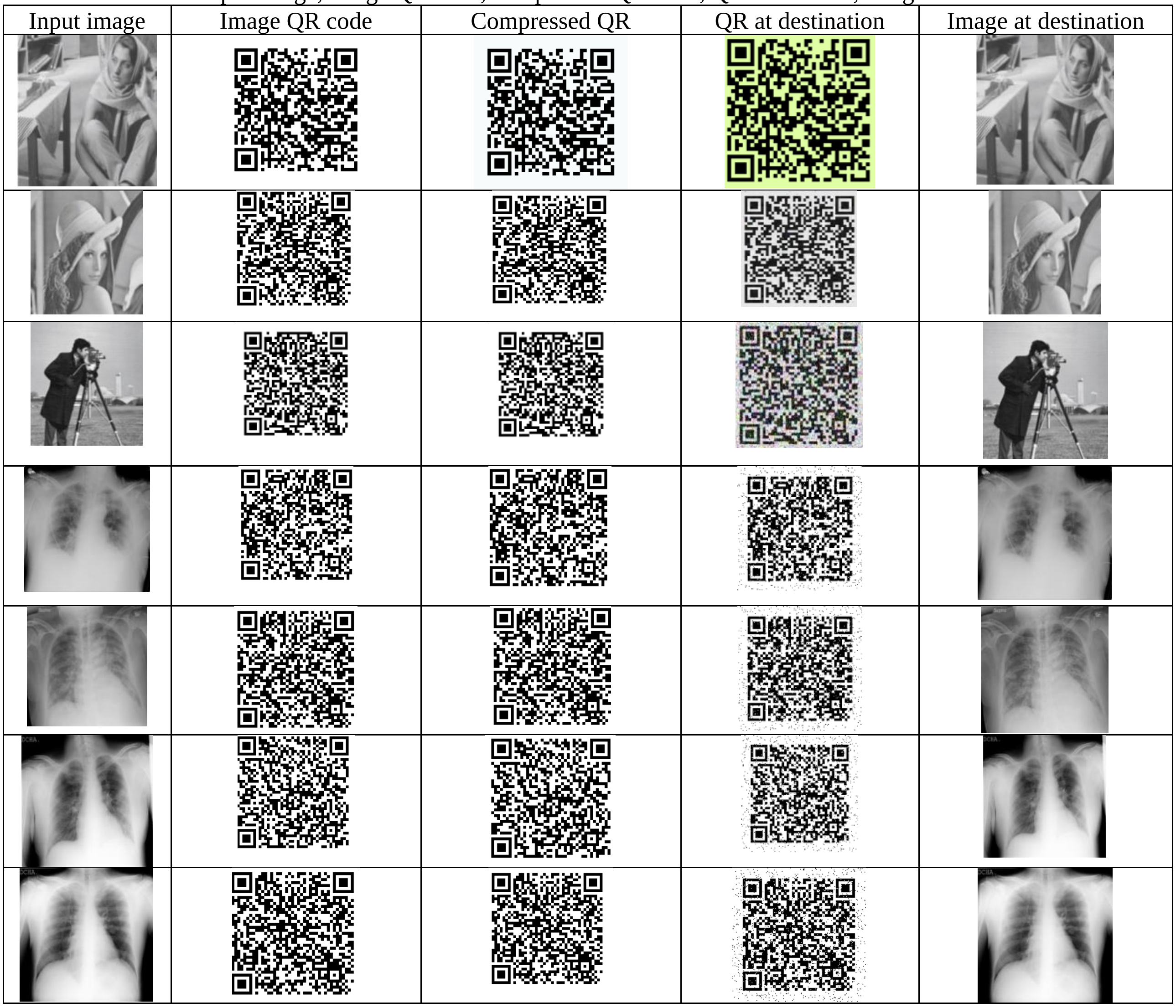

Table 3. Peak signal to noise comparative results

Image	ECIT [9]	EACIT [21]	EERP [29]	Proposed
Barbara	50.01	50.24	49.95	51.52
Lena	53.46	54.02	53.21	54.98
Cameraman	37.34	40.79	36.58	47.35
Image 1	38.61	50.21	37.98	51.48
Image 2	31.29	41.35	30.78	47.56
Image 3	37.28	49.86	37.01	50.56
Image 4	41.56	48.43	40.11	50.59
average	**41.36**	**47.84**	**40.80**	**50.57**

Table 4. Structural similarity index comparative results

Image	ECIT [9]	EACIT [21]	EERP [29]	Proposed
Barbara	0.901	0.916	0.892	0.919
Lena	0.926	0.934	0.921	0.964
Cameraman	0.854	0.876	0.849	0.896
Image 1	0.866	0.914	0.861	0.917
Image 2	0.744	0.873	0.739	0.893
Image 3	0.835	0.917	0.821	0.928
Image 4	0.894	0.904	0.834	0.921

Table 5. MSE comparison between two images

Image	ECIT [9]	EACIT [21]	EERP [29]	Proposed
Barbara	69.45	68.98	69.12	65.01
Lena	69.24	68.25	68.89	66.89
Cameraman	146.48	84.23	145.35	76.65
Image 1	134.58	68.58	134.06	65.26
Image 2	200.56	82.90	200.78	79.56
Image 3	135.41	69.26	135.08	66.59
Image 4	89.72	68.09	89.31	67.46

the original image with its auto error correction codes in it. The comparative analysis of structural similarity index and mean square error are described in Tables 4 and 5 respectively.

Up on comparison, the compressed QR code is found to have a maximum size of 2KB irrespective of the original picture's size and upon comparison

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with the original image this size is merely negligible and does not affect the network in terms of battery, and power consumption and increases network lifetime. During the transmission over the network various kinds of noises get added up with the image data and may be corrupted but the noise in the QR code data does not affect the original image in any of the small pieces as the actual image is safe aside. The energy consumption of the network with the proposed method was also found to be 39% less than the state-of-art methods on the other side the actual image to be transmitted was received with higher quality ever before.

6. Conclusion

In the proposed scheme any image with a huge size gets compressed to a limited size and upon using the discrete wavelet transform for compression, the image further gets compressed and as a result of less size of the transmission, the extent of noise to which it gets added doesn't effects. The help of which primary goals like higher quality reception, less energy consumption and time for transmission are achieved as better as expected and making the network more efficient than earlier. It is also found that the QR code obtained at the receiver is an average of 50.57dB of the original QR codes. This explains even with the less quality QR image where it got added up with noise can restore the original image. From the above observations, we have found that there is no compromise towards image quality. It is also found that as the size of the image to be transmitted is decreased drastically so the amount of power consumption reduces to a major extent. On the other side, along with the decreased energy consumption, the node's power usage decreases, which results in the node's battery remaining longer than earlier.

Conflicts of interest

The authors declare no conflict of interest.

Author contributions

The paper conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing-original draft preparation, writing-review editing and visualization, have been done by 1st and 4th authors. The supervision and project administration have been done by 2nd and 3rd authors.

References

[1] F. Ian Akyildiz, T. Melodia, and R. K. Chowdhury, "A survey on wireless multimedia sensor networks", *Computer Networks*, Vol. 51, No. 4, pp. 921-960, 2007.

[2] K. Bajaj, B. Sharma, and R. Singh, "Integration of WSN with IoT applications: a vision, architecture, and future challenges", *Integration of WSN and IoT for Smart Cities*, pp. 79-102, 2020.

[3] T. L. Mihai, "Internet of things low-cost long-term environmental monitoring with reusable wireless sensor network platform", *Internet of Things: Challenges and Opportunities*, pp. 169-196, 2014.

[4] A. Nosratinia, T. Hunter, and A. Hedayat, "Cooperative communication in wireless networks", *IEEE Communications Magazine*, Vol. 42, No. 10, pp. 74-80, 2004.

[5] G. L. Erik, O. Edfors, F. Tufvession, and L. T. Marzetta, "Massive MIMO for next generation wireless systems", *IEEE Communications Magazine*, Vol. 52, No. 2, pp. 186-195, 2014.

[6] C. G. Vehbi, B. Lu, and G. P. Hancke, "Opportunities and challenges of wireless sensor networks in smart grid", *IEEE Transactions on Industrial Electronics*, Vol. 57, No. 10, pp. 3557-3564, 2010.

[7] J. Abdallah, A. Sabbah, and M. Ibnkahla, "Data transmission reduction schemes in WSNs for efficient IoT systems", *IEEE Journal on Selected Areas in Communications*, Vol. 37, No. 6, pp. 1307-1324, 2019.

[8] D. Isabel and F. Dressler, "On the lifetime of wireless sensor networks", *ACM Transactions on Sensor Networks*, Vol. 5, No. 1, pp. 1-39, 2009.

[9] S. T. Abbas, H. J. Mohammad, J. S. Ahmed, A. S. Rashid, B. Alhayani, and A. Alkhayyat, "The optimization efficient energy cooperative communication image transmission over WSN", *Applied Nanoscience*, Vol. 13, No. 1, pp. 1665-1677, 2023.

[10] W. Wang, D. Peng, H. Wang, H. Sharif, and H. H. Chen, "Energy-constrained distortion reduction optimization for wavelet-based coded image transmission in wireless sensor networks", *IEEE Transactions on Multimedia*, Vol. 10, No. 6, pp. 1169-1180, 2008.

[11] T. Lang, Q. Zhao, and S. Adireddy, "Sensor networks with mobile agents", In: *Proc. of IEEE Military Communications Conference*, 2003.

[12] A. W. Pearlman, A. Islam, N. Nagaraj, and A. Said, "Efficient, low-complexity image coding with a set-partitioning embedded block coder", *IEEE Transactions on Circuits and Systems for*

Video Technology, Vol. 14, No. 11, pp. 1219-1235, 2004.

[13] A. S. Mahfuzul and D. M. Pham, “Energy efficient image transmission in wireless multimedia sensor networks”, *IEEE Communications Letters*, Vol. 17, No. 6, pp. 1084-1087, 2013.

[14] X. Xia, L. H. Man, and S. T. Wang, “Image filtering based on an improved spring-mass model”, *Journal of Algorithms & Computational Technology*, Vol. 5, No. 1, pp. 1-13, 2011.

[15] H. Sovannarith, C. S. In, and T. G. Nguyen, “Distributed image compression architecture over wireless multimedia sensor networks”, *Wireless Communications and Mobile Computing*, Vol. 1, No. 1, 2017.

[16] Y. A. U. Rehman, M. Tariq, and T. Sato, “A novel energy efficient object detection and image transmission approach for wireless multimedia sensor networks”, *IEEE Sensors Journal*, Vol. 16, No. 15, pp. 5942-5949, 2016.

[17] L. Vincent, C. D. Faundez, and N. Krommenacker, “Energy-efficient image transmission in sensor networks”, *International Journal of Sensor Networks*, Vol. 4, No. 1 pp. 37-47, 2008.

[18] W. Honggang, D. Peng, W. Wang, H. Sharif, and H. Chen, “Image transmissions with security enhancement based on region and path diversity in wireless sensor networks”, *IEEE Transactions on Wireless Communications*, Vol. 8, No. 2, pp. 757-765, 2009.

[19] L. J. Shyan and T. C. Lin, “An enhanced hierarchical clustering approach for mobile sensor networks using fuzzy inference systems”, *IEEE Internet of Things Journal*, Vol. 4, No. 4, pp. 1095-1103, 2017.

[20] B. A. Hayani and H. Ilhan, “Efficient cooperative image transmission in one-way multi-hop sensor network”, *The International Journal of Electrical Engineering & Education*, Vol. 57, No. 4, pp. 321-339, 2020.

[21] D. P. Kumar, P. P. Saradhi, M. S. Babu, and R. Sumalatha, “Energy aware cooperative image transmission for multi-radio multi-hop wireless sensor networks”, *International Journal of Intelligent Engineering and Systems*, Vol. 15, No. 4, pp. 43-52, 2022, doi: 10.22266/ijies2022.0831.05.

[22] D. P. Kumar, M. S. Babu, G. A. E. S. Kumar, and R. Sumalatha, “Optimal Relay Selection Strategy for Energy-Efficient Cooperative Multi-Hop Image Transmission in Wireless Multimedia Sensor Network”, *Cybernetics and Systems*, pp. 1-24, 2022.

[23] S. Phaisarn and W. Premchaiswadi, “QR-code generator”, In: *Proc. of 2010 Eighth International Conference on ICT and Knowledge Engineering*, 2010.

[24] S. Tiwari “An introduction to QR code technology”, In: *Proc. of 2016 International Conference on Information Technology (ICIT)*. pp. 39-44, 2016.

[25] D. P. Kumar, P. P. Saradhi, and M. S. Babu, “Energy efficient multi-hop cooperative transmission protocol for large scale mobile ad hoc networks”, *Wireless Personal Communications*, Vol. 121, No. 1, pp. 3309-3328, 2021.

[26] K. D. Praveen and P. P. Saradhi, “An efficient cooperative routing algorithm for large-scale wireless networks based on capacity and location”, *International Journal of Communication Networks and Distributed Systems*, Vol. 26, No. 4, pp. 446-463, 2021.

[27] L. Xiangling, T. Xiaofeng, and N. Li, “Energy-efficient cooperative MIMO-based random walk routing for wireless sensor networks”, *IEEE Communications Letters*, Vol. 20, No. 11, pp. 2280-2283, 2016.

[28] H. Alain and D. Ziou, “Image quality metrics: PSNR vs. SSIM”, In: *Proc. of 2010 20th International Conference on Pattern Recognition*, 2010.

[29] A. A. As’ari, N. I. A. Apandi, N. A. Muhammad, R. A. Rashid, M. A. Sarijari, and J. Salleh, “Energy efficiency scheme for relay node placement in heterogeneous networks”, *Bulletin of Electrical Engineering and Informatics*, Vol. 12, No. 1, pp. 187-195, 2023.