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IMAGE COMPRESSION ALGORITHM FOR ENERGY EFFICIENCY OPTIMIZATION IN WIRELESS SENSOR NETWORKS

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Abstract

Wireless Sensor Networks (WSN) enable fine- grained environmental monitoring. Sensors, on the other hand, have energy, computational resources, storage, and many other physical limits. Techniques must be devised to increase the limited resource available in a sensor network efficiently. This research intends to improve energy efficiency and resolving transmission issues that occur in wireless sensor networks through a study on hybrid Embedded Zero-Tree Wavelet (EZW) and Set Partitioning in Hierarchical Trees (SPIHT) image compression algorithms. The suggested technique, which combines Dual Image Compression Techniques (DICT), is a promising technique for image compression that transmits only the difference between the images only to the receiver and thus reducing the percentage of bits necessary to exemplify the input for transmission while maintaining high image quality during reconstruction.

Keywords: *Dual Image Compression Techniques, Wireless Sensor Network, EZW, SPIHT, Physical Constraints.*

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1. Introduction

Sensor networks have cost effective nodes operated by rechargeable or non-rechargeable batteries depending on where it is deployed, that can be utilised for distant object tracking and monitoring in a variety of applications in different environments. Sensors have distinct restrictions because of their affordable cost and low intricacy, including a restricted transmission distance, inadequate computing and processing capacity, minimal dependability and information transfer speeds, and finite feasible energy. Multiple sensor networks must be created with a goal of overcoming those obstacles by utilizing the energy among dispersed nodes. Although computers are significantly agile than humans,they fall short when it comes to picture processing since images take a lot of processing. Because sensor nodes have limited battery capacity, it is preferable to have light weight compression images for processing the image at the sensor node. Because an image contains a lot of data, the amount oftime it takes to compress increases the communication overhead and this must be reduced.

Transmission of data, mostly images and text, is one of a node's most energy intensive functions. It is obvious that compressed image communication is proved to be highly energy conserving when compared to direct image transfer in absence of compression. With image compression, energy is saved by lessening the amount of bits delivered to the destination end.

2. Literature Survey

This section discusses the contributions by the researchers in WSNs using various techniques of compressing the images in sensor networks.

Jeongyup Park, et. al, developed an image compression approach in [1] for image-based WSNs utilizing K-means clustering. Their findings imply that the expense of executing K-means learning on a node may surpass the advantage of data compression, while that loading the learning process and only compressing the data can save significant energy. Low-power embeddedcomputer platforms are connected to a variety of sensors to capture data from the real environment, allowing for the integration of a variety of applications.

A study by Mou Wu, et. Al, in [2] introduced a unique framework that combines data forecasting, compression, and data redemption in a clustered WSN to improve data processing accuracy and efficiency. The framework's major purpose is to reduce transmission costs while maintaining the accuracy of data interpretation and prediction. Data prediction is done in this research analysis by applying the Least Mean Square (LMS) algorithm with dual prediction and by reducing the mean-square derivation (MSD) with thestep size that is optimal, in such a way that the cluster headis not affected.

Mark Coats Worth, et. al, in [3] proposed a blend of compression technique for streaming RGB-d data instantaneously. They looked at the feasibility and usability of stay-streaming RGB-d data in worst-case scenarios in this study, which discussed a blend of compression technique, which is both lossless and lossy specifically for RGB-d data. These findings demonstrate that RGB-D streaming is both achievable and beneficial to be established for on-hardware network systems.

For Multi-Sensing Wireless Sensor Networks, an adaptive framework that selects the sensor based on some learning has been developed by Sushmita Ghosh, et. al in [4]. This research proposes a novel adaptive sensor selection strategy to reinforce the sustainability of sensor hubs. With many sensors monitoring different characteristics in the same environment, the device can cross-correlate and forecast. In order to do this, a learning-based fully optimized approach is devised, which uses an Upper Confidence Bound (UCB) of rules to pick an optimum active sensor from a set in a monitoring routine based on cross- correlations of a part of the node's properties.

Chandan Singh Rawat, et. al, in [5] proposed a blended compression scheme using Discrete Cosine Transform (DCT) and Fractal Image Compression. Color images were efficiently compressed utilizing DCT in this proposed technique. In general, blocking artefacts appear when using a DCT-based compression approach. The fractal image compression method was used to reduce artefacts in this example. The Euclidean distance measure was also usedto discover the self-similarity between the analogue pieces. As a result, the compression of comparable blocks is no longer necessary.

Sunil Kumar, et. al, in [6] suggested that through the use of wavelet transforms, this work deals with a specific type of compression technique. Wavelets describe a sequence of simple patterns and coefficients that make up a complicated pattern which when expanded and summed, duplicate the original sample. Lossless and lossy compressions are the two types of data compression algorithms. Lossycompression is typically superior to lossless compression in terms of compression quality. Wavelets are a type of features that can be used to pinpoint the location of a signal in different space and magnitude domains.

WSN congestion control routing that is energy-efficient and mostly based on control rules are proposed by Srivastava, et.al in [7]. To lower the energy usage throughout the networks, a set of traffic control and management rules based on data rate and mostly based on cluster routing, has been added. The rate control mechanism minimizes the source to destination delay, allowing the network to last longer over a longer simulation period. The blended K-means and Greedy First-rate First search methods are usedto cluster nodes in the beginning. The rate control is accomplished with the help using the firefly optimization method that makes it suitable for excellent packet delivery ratios. Finally, Ant Colony Optimization-primarily focused on routing is used to send packets with the highest throughput possible. In [8], a series of image compression techniques for WSNs are proposed with its advantages and limitations. Analysis of DWT with various wavelet filters are discussed in [9] like Biorthogonal, Daubechies, etc and based on the optimization using the several parametric values, Biorthogonal is more promising in terms of PSNR. Texture restoration techniques for effective image reconstruction using deep neural networks for these types of networks was discussed in [10], the applications of CDF filter were discussed in [11], that proves that with the help of appropriate quantization step size, provides more amount of compression. A procedure was discussed in [12] that select the cluster head based on a protocol.

3. Proposed System

One of the most critical elements affecting the sensor network's lifespan is energy usage and energy efficient data transfer. Like a security camera set in a room, the camera equipped nodes are always in the same place. Every node with a camera can make a response to the query initiated for an image by creating an unprocessed image and sending it to the sink node after compressing (destination). The procedure is as follows:

i. In a concentrated region, all Sensor Nodes (SN) are distributed at random manner.
ii. A network with two group of sensor nodes (SNs): Camera Sensor Nodes (CNs) and Conventional Sensor Nodes (NNs).
iii. There are fewer Camera Nodes than Normal Nodes and Normal Nodes are homogeneous in every category and they all have equal initial energy, computing power, storage requirements and so on.
iv. After deployment, all Sensor Nodes are oblivious of their location and become static.
v. The communication range of all Sensor nodes was the same (radius= RC).
vi. Each Sensor Node can estimate the distances to other Sensor Nodes, based on the Received Signal Strength Index (RSSI) value.
vii. A single base station is placed outside the coverage region and equipped with appropriate components.
viii. The functioning of the network is completed in a single round. One round is believed to be the transmission of an image from a source node to base station.

Camera Cluster

The proposed methodology for testing wireless sensor networks in image compression algorithms is depicted in Fig. 1. A camera cluster consists of one CN and a large number of neighbouring Normal Nodes, which serve as broadcast nodes [12]. CN optimization is tough to do in this cluster since the energy of each node changes frequently. Furthermore, a small coverage area can result in an insufficient number of sensor nodes for processing or transferring data, whilst a huge coverage area can result in more energy being required for transmission to its node.

Image Compression Cluster

At some point during data transfer, the image compression cluster is formed. This cluster is used to compress images before sending them to the base station. The cluster head of image compression cluster ICH is picked from among the camera cluster's highest-energy nodes. Members of the image compression cluster are known as NBICHs (Neighbouring Node Image Compression Cluster Heads).For image compression and transmission to the node, EZW+SPIHT are employed.

Image Communication Cluster

All Sensor Nodes are arranged into groups called clusters for energy efficiency. Many Nodes make up a group of Senor Nodes, but only one is chosen to be the cluster head (CH),and the others are member nodes. The data is sent frommember nodes to their Cluster Head, who then transmits it to the next destination.

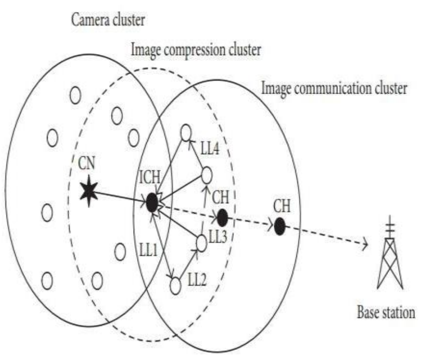

Figure 1: Proposed Methodology for Testing

This work presents the development of compression technique based on dual compression and has a very powerful advantage on achieving redundancy reduction of data, and in turn the image distortions will not influence the quality of image during reconstruction. The steps given are as below:

Step 1: Capture the image which is an uncompressed image.

Step 2: Compress the original image component with Set Partitioning in Hierarchical Trees (SPIHT) compression procedure with bior 1.1 wavelet filter.

Step 3: The result from step 2 will be compressed, by using a progressive compression method EZW (Embedded Zero trees) with Haar wavelet method.

Step 4: Transmit the compressed image

Step 5: Calculate Compression Ratio for the compressed image.

Step 6: Perform dual decompression; first with EZW and then with SPIHT algorithms and compare it with the actual image.

4. Results and Discussion

Only the modifications in the images are used to send the entire image. The minor modifications are then quantized and subtracted from the original images before being sent back to the destination. The pictures are recomputed at the destination, and the legitimate reconstructed image is returned. The picture quality criteria are easily implementedwith this technique. Our strategy, according to simulation data, will enhance the performance of the network significantly. The system is divided into three phases: (i). Source image side, where an image is captured which is a response based on a request from the target user and compresses it. (ii). Medium, to transfer the compressed data towards the destination, and (iii). Destination side, where decompression is performed using the proposed method.Because the node has been anchored, there are no variationsin the latest image saved, except for the addition of a node afresh. So, rather than transmitting the entire image, only the changes are compressed and transmitted. The energy efficiency of camera-equipped sensor network nodes will be improved through simulation. The proposed SPIHT + EZW technique is relatively convenient and feasible, and it provides a best outcome in terms of processing power. For routing the state of the art Least Energy Adaptive Clustering Hierarchy (LEACH) methd is used and the node graph view is depicted in Fig 2. A set of 9 nodes are randomly deployed and the process of data transmission is shown in Fig 3.

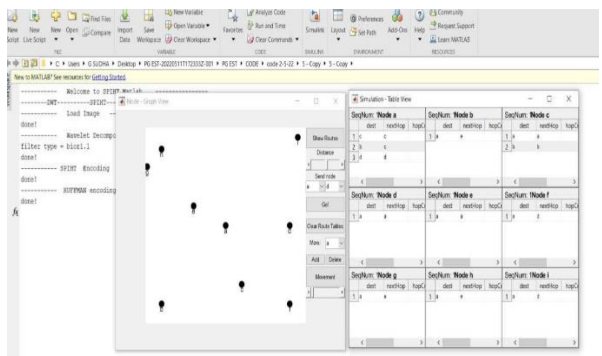

Figure 2: Node Graph View

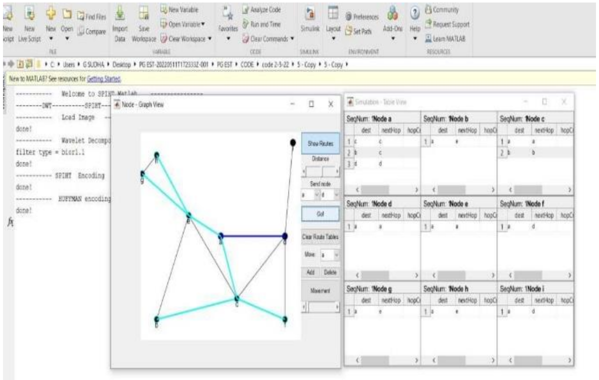

Figure 3: Data Transmission

For image compression, the process first goes through SPIHT encoding process. The resultant image is then compressed again using EZW technique. The wavelet decomposition applied in the beginning of the encoding is Discrete Wavelet Transform (DWT), which will decompose the image into many levels of decomposition. The proper level of decomposition is chosen depending on the required level of image clarity after reconstruction. Though the process involves dual compression which may prolong the encoding and the decoding process, the result produced is more promising in terms of compression ratio, Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR). This dual process is tested with the standard images of size 512 x 512 as in Fig 4 and the resultant values are tabulated in Table 1 and Table 2. The sample image encoded and decoded using the proposed algorithm is shown in Fig 5 and Fig 6 respectively.

Figure 4: Standard Image Set

Table 1: Comparisons of the Simulation Parameters

Image Name	PSNR (dB)	CR (%)	MSE	SSIM
Lena	37.11	17.541	11.57	96.87
Barbara	30.01	89.632	64.81	98.7
Cameraman	36.61	70.02	16.85	96.95
Vegetable	25.51	57.5	18.85	98.2
Boat	37.76	133.998	8.85	98.96

Table 2: Comparisons of bpp and Throughput

Image Name	Bits per Pixel (bpp)	Throughput (bits / sec)
Lena	1.4	182
Barbara	7.17	185.5
Cameraman	5.14	184.5
Vegetable	7.77	180
Boat	10.72	182.01

Figure 5: Encoding of Lena Image

Figure 6: Decoding of Lena Image

Based on the study, the dual algorithm PSNR, CR, SSIM, MSE shows the best values. This can be compared with the already existing methods with different wavelet filters in theDWT stage for future work. The tabulated values are given as a consolidated bar chart in Fig 7.

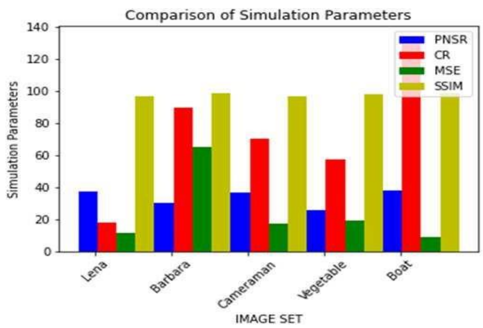

Figure 7: Comparison of Simulation Parameters

5. Conclusion and Future Scope

As the simplest of its kind, the proposed technique provedto be quite beneficial in the study of picture compression. The image is compressed with the EZW and SPIHT algorithms, and then delivered over WSN nodes. Using encoding, the proposed strategies can compress a variety of images at different quantization values. In comparison to DCT, the compressed file utilizing the suggested methodologies provides good compression with good imagequality, and the compressed image sent from the node takes minutes and time to reach the destination. In the future, we plan to apply these findings to other literature-based quick implementation methodologies and real-world sensor platforms. Furthermore, we intend to put our approach into practice on a specific platform for Multimedia Wireless Sensor Networks (MWSNs).

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