EFFICIENT IMAGE AND MULTIMEDIA TRANSMISSION THROUGH WIRELESS SENSOR NETWORKS-A SURVEY

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***Abstract*— Wireless Sensor networks are battery powered due to which their lifetime is precisely limited. In this type of network, the nodes commonly have very limited resources in terms of processing power, bandwidth, and energy. Efficient coding of the image and multimedia content is, therefore, important. One possible way to achieve maximum utilization of those resources is applying compression on sensor event. Usually, processing data consumes much less power than transmitting data in the wireless medium, so it is effective to apply compression before transmitting data for reducing total power consumption by a sensor node. In this paper various energy efficient image compression techniques such as Collaborative image transmission using Sobel edge-detection, JPEG2000 image compression techniques-DWT and DCT, Image Subtraction with Quantization of the image, EBCOT, Face Coding and Spatial Correlation-Based Image Compression are discussed. Different compression techniques deal with different levels of image or multimedia quality, transmission time and memory space. Another important issue is the delay in transmission and this problem can be reduced by using efficient protocols in transport and network layers. In this paper, various routing protocols used in different layers are also discussed.**

Keywords— Wireless Sensor Networks, Compression, DWT & DCT, JPEG2000, EBCOT, Face Coding, Routing.

I. INTRODUCTION

In the recent years, the wireless technology would have known an exponential growth, which has an impact on developing and improving the field of telecommunication beyond the means of transmission wire to the radio frequency communication. Advances in wireless communication have enabled the development of low-cost, low-power visual multihop wireless networks, which have recently emerged for a variety of applications, including environmental and habitat monitoring, target tracking, surveillance and emergency response. The Wireless Sensor Network (WSN) is a collection of component (nodes) organized into a cooperative network [1]. A Wireless Sensor Network is a self-configuring network of small sensor nodes communicating among themselves using radio signals, and deployed in quantity to sense, monitor and understand the physical world. Wireless Sensor nodes are called motes. WSN provide a bridge between the real physical and virtual worlds. It has a wide range of potential applications to industry, science, transportation, civil infrastructure, and security [9].

Image or multimedia transfer in WSNs presents major challenge which raises issues related to its representation, its storage, and its transmission. Uncompressed data (graphics, audio, and video) requires considerable storage capacity and transmission bandwidth. The demand for data storage capacity and data transmission bandwidth continues to outstrip the capabilities of available technologies, yet there is a rapid change in terms of the mass storage density, processor speed and system performance digital communication. Previously, capturing data from the natural or built environment was not possible, but actually, with Wireless Sensor Networks (WSN), which is a new tool to sense all type of data, all is possible. In WSN, a tiny embedded device has the capability for sensing, processing, and wireless communication. It is predicted that wireless sensor networks (WSN) will become ubiquitous in our daily life and they have already been a hot research area for the past couple of years [10].
As the radio transceiver is one of the most powerful greedy components of sensor nodes, compression seems a natural answer to the image transmission problem over a WSN. Unfortunately, most of the compression algorithms are inapplicable on sensor nodes which are due to resource limitation in terms of memory or processor speed. As a consequence, special challenges for energy efficient image compression in WSNs must be addressed to maintain a long network lifetime. Nodes are powered by small batteries which generally cannot be changed. The application of multimedia (image, video, etc.) on wireless sensor networks is being, these days, a great requirement for the research and industrial community. The current researches deal with image processing like data extraction, image processing, and analysis. Thus, the case of image compression and image transmission over WSN is not a new concept because there are many researchers who worked on it [4].

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In this paper, various approaches related to compression and routing are discussed. The implementations of these methods on a real wireless sensor platform are allowed to reconcile with the real problems related to image processing applications.

II. COMPRESSION BASED ALGORITHMS

2.1 Collaborative Image Transmission Using Sobel Edge Detection

A novel distributed image compression is examined [7] for wireless sensor networks to avoid the extra energy usage during redundant data transmission. First, a shape matching method to coarsely register image is applied by sharing shape context to avoid communication overhead. The Image is divided into sub-regions based on the gray scale value and quantization methods are performed on sub-regions. This load is shared on the overlapping camera node. The Image in the neighbour sensor is spatially correlated with overlaps. A common region of overlapped area is identified by sharing low bandwidth descriptors as feature points.

Sobel edge-detection is used to extract the feature points so that the communication overhead between sensor nodes can be reduced. This is done in order to reduce the redundant data in the images and hence life time is increased. The discussed approach is feasible for the image that has large regions and low variation. This is due to the quantization based on the regions. It is more feasible for low contrast images [7].

2.2 Discrete Wavelet Transform (DWT) and Embedded Block Coding with Optimized Truncation (EBCOT)

To reduce the energy consumption of the sensor network during image transmission, Mohsen Nasri, Abdelhamid Helali, Halim Sghaier & Hassen Maarefan [8] proposed an energy efficient image compression scheme. The image compression scheme reduces the required memory. JPEG2000 provides a practical set of features, not necessarily available in the previous standards.

These features were achieved using techniques: the Discrete Wavelet Transform (DWT), and Embedded Block Coding with Optimized Truncation (EBCOT).

Initially, Wavelet Transform is performed on the images. After the DWT, all the sub-bands are quantized to reduce the precision of the sub-bands and contribute in achieving compression. In the Embedded Block Coding method which is used in JPEG2000 standard, each sub-band is divided into small blocks called 'code blocks'. And then each code block is coded independently to better compress the images [8]. The following flowchart provides the working of this mechanism.

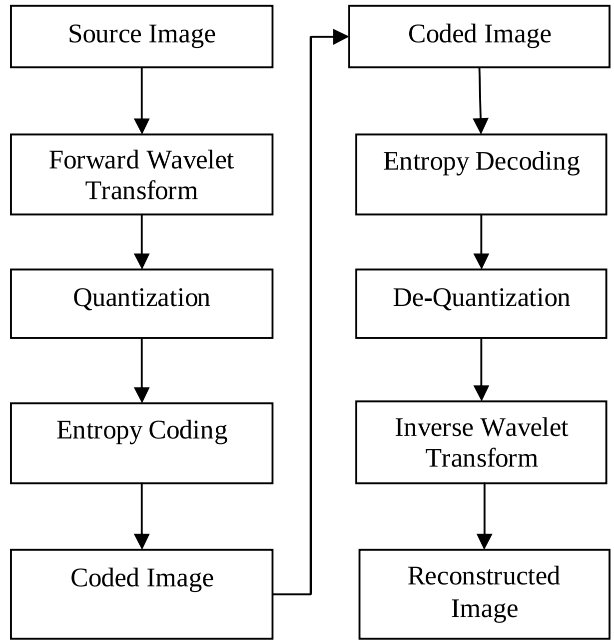

Fig 1: Flowchart for EBCOT

2.3 Discrete Wavelet Transform & Discrete Cosine Transform

Two image transmission scenarios which are based on discrete wavelet transform (DWT) and discrete cosine transforms (DCT) driven by energy efficiency considerations suitable for WSN were proposed in [10]. DWT is an operation that is applied to the entire image and allows image decomposition into separable sub-bands for multi-resolution representation purposes.

DCT is applied on each block with size 8x8 and not on the entire image which allows a high compression ratio [10]. The following table provides a comparison between these two approaches based on compression ratio, execution time and memory used.

Table No.1: Comparative Analysis for DWT & DCT

EFFICIENCY CRITERION	**DCT**	**DWT**
Compression Performance	+++	+++++
Memory Used	+++	+
Execution Time	+	+++

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In the above table, symbol '+' is used to differentiate the efficiency criterion of the two different algorithms Discrete Cosine Transform and Discrete Wavelet Transform. If the number of '+' increases it indicates that its efficiency is greater than the other one.

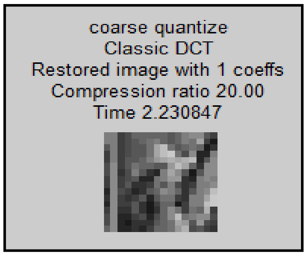

Fig.2: Classic DCT

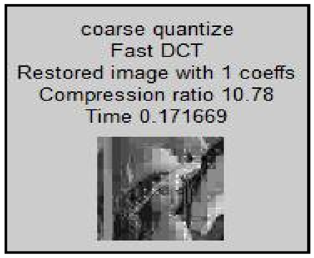

Fig.3: Fast DCT

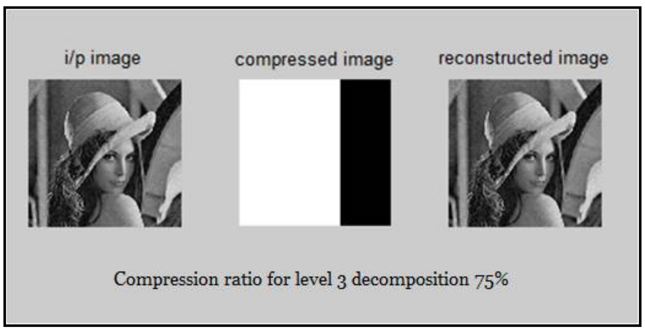

Fig.4: DWT

Table No.2: Comparative Analysis for DWT & DCT Based on the PSNR Values

PEAK SIGNAL TO NOISE RATIO (PSNR) (dB)	
DISCRETE COSINE TRANSFORM	DISCRETE WAVELET TRANSFORM
5.6192	3.2122
5.7709	4.1123
6.9759	4.2334
7.0122	5.2235
7.8500	6.1104
9.3232	6.4532
6.2112	2.1109
6.4352	3.0978
5.6120	3.2201
6.2723	4.2213

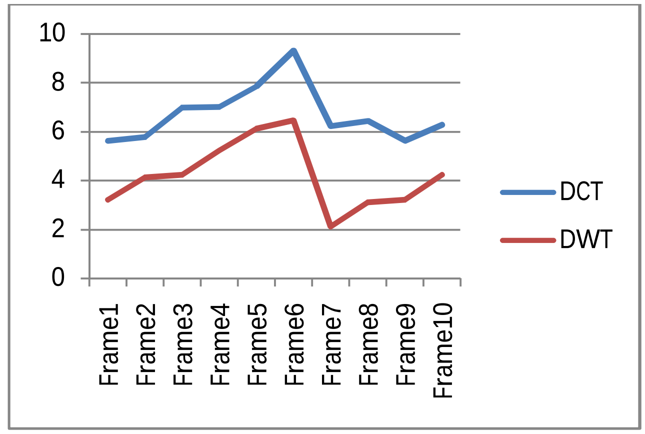

Fig. 5: Graph Representing the PSNR values of DCT & DWT

2.4Spatial Correlation Based Image Compression

Pu Wang, Rui Dai, Ian F. Akyildiz [11] proposed spatial correlation-based image compression framework mainly to maximize the compression of visual information gathered in a WMSN. This framework consists of two components: 1) compression efficiency prediction and 2) coding hierarchy construction. The compression efficiency prediction aims to estimate the compression gain from the joint encoding of multiple cameras before the actual images are captured. To achieve this, an entropy-based divergence measure (EDM) scheme is proposed, which only takes the camera settings as inputs without requiring the statistics of real images.

Based on the correlation characteristics, a dependency graph based algorithm is designed to estimate the joint entropy of multiple cameras. This joint entropy effectively predicts the compression performance for joint encoding of multiple cameras. Using the results from EDM, the next problem is how to establish a compression-oriented coding hierarchy, which can achieve a substantial compression gain and decode reliability [11].

2.5Bayesian Technique with Discrete Wavelet Transform

In paper [1] a new scheme that has two stages was proposed. In the first stage, pre-processing using Bayesian technique is performed and in the next stage, wavelet based compression is done. An efficient Wavelet based compression scheme that can significantly minimize the energy required for wireless image communication while meeting bandwidth constraints of wireless and network image quality.

Based on Discrete Wavelet Transform, an efficient image compression scheme, enabling a significant reduction in computation energy needed with minimal degradation of image quality is proposed which provides better compression ratio and reduced transmission delay [1].

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2.6 Knowledge Based Coding Techniques (Face Coding)

Luis Torres and Edward J. Delp in their paper suggested a new technique called Face Coding. As the name suggests the video sequence containing the face images is taken. Initially, PCA is done before the encoding process. Face detection algorithms are used and for reconstruction Eigen faces obtained from PCA is used. Eigen faces should be sent previously to the decoder for reconstruction process [6].

2.7 Image Subtraction with Quantization of Image (ISQ)

A novel technique, Image Subtraction with Quantization of the image (ISQ) is proposed in [13]. In this technique, only the changes in the image are sent back instead of sending back the whole image. Then the small changes are extracted from the original images and then send back to the destination by quantizing the small changes.

In the destination, the images are recomputed and then the original reconstructed image is got back.

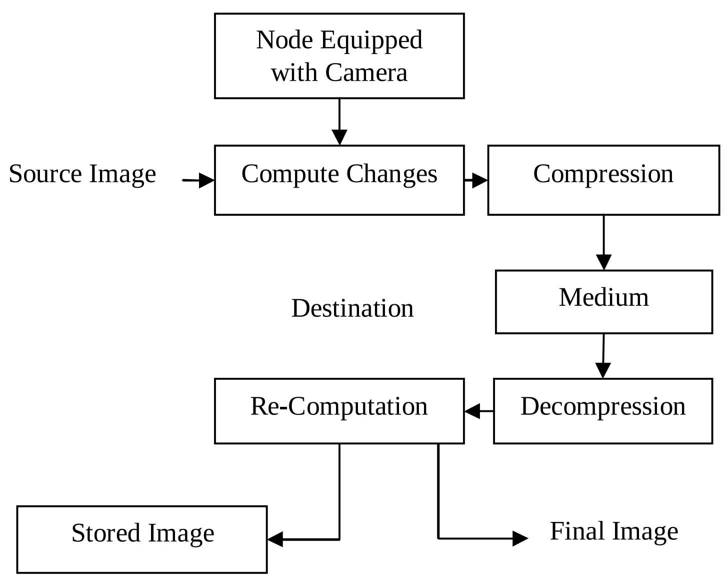

Fig.6: Flowchart for ISQ

The system structure shown is divided into three phases, source image side, where an image is generated after query from the destination, and compressed by using the proposed method (ISQ), medium where the compressed image node by node moved towards destination node, and destination side, where decompression is applied according to the proposed method. Through simulation, it is shown that ISQ improves the energy efficiency of a camera- equipped node of the sensor networks [13].

2.8 Pipelined Codebook Compression and Entropy Encoded Codebook Compression with Shortest Path Routing

The proposed approach in [12] describes the design and implementation of the two lossless data compression algorithms integrated with the shortest path routing technique to reduce the raw data size and to accomplish optimal trade-off between rate, energy, and accuracy in a sensor network. In the Pipelined Codebook Compression method the collected sensor data packets are aggregated, combined into a single packet, and redundancies in the data packets are removed to minimize data transmission. The compression is done by checking all the most significant bits of the packets and combining the packets which have the same most significant data bits. After the data packets are merged the resultant data is again compressed by using Entropy Encoded Codebook Compression method.

Table No. 3: Compression Based Algorithms

Author	Techniques	Year	Features
M. Sher[13]	Image Subtraction With Quantization Of Image	2009	Energy Efficiency and Increased System Lifetime
Ranganathan Vidhyapriya [12]	Pipelined Codebook Compression and Entropy Encoded Codebook Compression	2009	Energy Efficiency, Low Latency, and High Accuracy
M.I.Razzak [7]	Sobel Edge-Detection	2010	Reduce Redundancy, Life Time Increased and Feasible for Low Contrast Images
Mohsen Nasri[8]	Discrete Wavelet Transform (DWT) and Embedded Block Coding With Optimized Truncation (EBCOT)	2010	Low Energy Consumption and Memory Used
Pu Wang[11]	Spatial Correlation-Based Image Compression	2011	High Compression Ratio and Reliability
Arputha[1]	Bayesian Technique With Discrete Wavelet Transform	2012	Image Quality, Transmission Delay, Compression Ratio and Energy Efficiency
Luis Torres and Edward J. Delp [6]	Face Coding	2012	High Accuracy
Oussama Ghorbel[10]	Discrete Wavelet Transform & Discrete Cosine Transform	2012	High Compression Ratio, Execution Time and Memory Used.

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III. ROUTING BASED ALGORITHMS

3.1 Zigbee Networks

An image sensor network platform is developed by Georgiy Pekhteryev, Zafer Sahinoglu, Philip Orlik, and Ghulam Bhatti in the paper [2] for testing transmission of images over ZigBee networks that support multi-hopping. The ZigBee is a low rate and low power networking technology for short-range communications, and it currently uses IEEE 802.15.4 MAC and PHY layers. Both ZigBee networking (NWK) and IEEE 802.15.4 MAC layer protocols are implemented on a single M16C microprocessor. Transport layer functionalities such as fragmentation and reassembly are performed at the application layer since the ZigBee NWK does not have a fragmentation support. The multiple access scheme is CSMA/CA, therefore only the best effort multi-hop transmission of JPEG and JPEG-2000 images are tested.

Hyun-Soon Son, Jeong-Hyeon Park, and Sung-Keun Lee proposes the enhanced transmission protocol that can transmit image data effectively as well as various scalar sensing data in WSN. The proposed protocol consists of application protocol that marks packet quality level for the differentiated transmission of scalar data and image data and network protocol that routes packets according to the quality level. As the results of performance analysis through simulation method, the average packet delay decreased 35% when comparing to existing shortest path protocol regarding proposed protocol and the packet loss rate improved largely [3].

3.2 Reliable Asynchronous Message Transfer (RAIT)

Joa-Hyoung Lee and In-Bum Jung [5] proposed a reliable asynchronous image transfer protocol, RAIT. RAIT applies a double sliding window method for node-to-node transfer, with one sliding window for the receiving queue, which is used to prevent packet loss caused by the communication failure between nodes, and another sliding window for the sending queue, which prevents packet loss caused by network congestion.

The routing node prevents packet loss between nodes by the pre-emptive scheduling of multiple packets for a given image. RAIT implements a double sliding window method by means of a cross-layer design between the RAIT layer, routing layer, and queue layer. The authors demonstrate that RAIT guarantees a higher reliability of image transmission compared to the existing protocols [5]. The following flowchart illustrates the working of RAIT protocol.

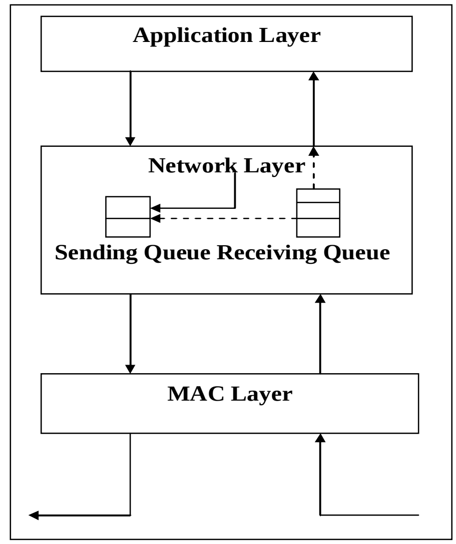

Fig.7: Flowchart for RAIT

Table No. 4: Ruting Based Algorithms

Author	Techniques	Year	Features
Ranganathan Vidhyapriya [11]	Shortest Path Routing Technique	2009	Energy Efficiency, Low Latency and High Accuracy
Georgiy Pekhteryev[2]	Zigbee Networks	2005	Low cost and Low Power Consumption
Hyun-Soon Son[3]	Transport and Application layer Protocols	2015	Packet Loss Rate and Packet Delay
Joa-Hyoung Lee[5]	Reliable Asynchronous Image Transfer (RAIT)	2010	Packet Loss Rate and Reliability

IV CONCLUSION

In this paper various image compression schemes - Collaborative image transmission using Sobel edge-detection, JPEG2000 image compression-DWT and DCT, Image Subtraction with Quantization of the image, EBCOT, Face Coding and Spatial Correlation-Based Image Compression are analyzed based on their compliance to wireless sensor network. Compression ratio and power saving manners in these schemes are highly efficient. Also to reduce the transmission delay some of the routing algorithms were discussed in this paper. Some of the approaches are the shortest path Routing protocol, Zigbee networks and RAIT protocol. These methods are one of the possible methods to diminish resource constraints of wireless sensor nodes in combination with energy-efficient clustering mechanism.

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