The Image Compression Methods In Wireless Multimedia Sensor Networks

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ABSTRACT: *Wireless multimedia sensor networks (WMSN) are a special case of wireless sensor networks, they differ from wireless scalar network primarily in very large memory resources, the nature and volume of the data transmitted, and the energy consumed by each node during the computation and communication. The need to compress images seems unavoidable today. Currently, compression is always performed without loss when it exists because it is so far the only type of compression tolerated by experts. Indeed, lossless compression ensures data integrity and prevents errors. However, this type of compression does not provide significant reduction in the volume of data. In this context, lossy compression may be the most appropriate response. Several compression algorithms have been developed. The objective of this work is to study the major relevant research directions and the latest algorithms for image compression in WMSNs.*

Keywords: Compression Methods, Energy Consumed, WMSN, Lossy Methods

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1. Introduction

Grace to recent technological advances, especially in the field of manufacturing semiconductors, electronic equipment has become smaller and cheaper. One area that has benefited most from these developments is the domain of Wireless Multimedia Sensor Networks (WMSN). Wireless multimedia sensor networks have a number of features which require changes in some aspects such as the transmission of image. As the image contains a set of pixels are correlated with each other. However, because of this correlation; [01] contains a large amount of redundancy occupying the mass storage space and minimizes the transmission bandwidth. There are three types of data redundancy, (1) spatial redundancy: repeated data neighboring pixels are correlated unnecessary way within a framework should be removed to reduce the size of the image. (2) Temporal Redundancy: representing the image data, it is necessary to reduce the number of bits needed to represent the image. (3) Spectral Redundancy: is the correlation between different color planes. In order to overcome those redundancies, principle objective of compression is to reduce the size of storage and transmission of data in a minimum bandwidth while maintaining acceptable visual quality of reconstructed image close enough to the original image.

In multimedia wireless sensor networks (WMSN), image compression is to solve some problems such as limited memory resources and reduce the size of data transmitted, all this means minimizing the energy consumed by each node during processing and transmission.

Generally, compression techniques can be classified into two: lossy and lossless. The benefits of the first technique compared to the second are the highest compression ratio, and to reduce the time in both directions (encoding and decoding) to be fast and asymmetric.

This paper organized as follows, in first section Application areas; we mention some of new areas in which we use the WMSN. In next section, basic Concepts, we will see general principle of image compression, performance measures of image compression and a simple comparison between WMSN and WSN scalar. In 3rd party The image compression methods in wireless Multimedia Sensor Networks: A SURVEY, we realize a synthesis of several research studies related to image compression in wireless multimedia sensor networks, and we make a synthesis of several research studies related to image compression in sensor networks Wireless Multimedia, and we speak of lossy compression methods especially Transform-based techniques and we also have a comparative study of the three methods DCT, SPIHT and EBCOT, in terms of Energy consumption, quality of the output image, complexity method, memory requirements, and compression ratio .

2. Application Areas

The multimedia sensor network wireless (WMSN) attracted the attention of the research community in recent years, driven by a host of theoretical and practical challenges. WMSN will not only improve the sensor network applications such as monitoring, home automation and monitoring of the existing environment, but they also enable many new applications such as:

WMSN for monitoring: Wireless video sensor networks will be composed of interconnected, miniature video camera batteries, each packed with a transceiver without low power wire that is capable of processing, sending and receiving data. [2] Multimedia sensors will be used to complement and enhance existing surveillance systems against terrorist attacks and crime of all kinds. Networks of large-scale video sensors can extend the capacity of law enforcement agencies to monitor areas, public events, private property and the border. For example,[23] to secure the area where you want to make the New York marathon, organizers installed Sony IP cameras connected to a network wireless mesh Firetide.

Figure 1. Sony IP cameras monitor the New York marathon route

Storage of Potentially Relevant Activities: Multimedia sensors could reduce and save potentially relevant activities (flights, car accidents, traffic violations), and make video / audio stream or reports available for future query. [24]As road surveillance camera, is a video monitoring system of road traffic. It can be of 2 types, cameras to detect traffic offense and cameras to detect an incident or an accident on the road network

Applications Sports: The evolution of sensor networks is used more and more in sports, namely monitoring systems, trajectory

Figure 2. Intersection Cameras

calculation systems as, [22] In football, detection systems errors arbitration as technology on the goal line (goal-line technology or goal decision system) is an electronic device and / or video assistance to arbitration, used to determine for certain whether a ball has crossed fully or not the goal line.

Figure 3. Goal Line Technology

Medical Applications: [20,21] In the field of medicine, multimedia sensor networks can be used for continuous monitoring of physiological data collected by the sensors can be stored for a long time to monitor a patient for further medical decision, the establishment of a health monitoring device to the arrival of flights from the areas affected by Ebola.

Figure 4. Medical Supervision Airport, Feverscanm3000

Military Applications: [4][25] Wireless sensor networks can be integral modules in Military Systems Command, control, communications, computing, intelligence, surveillance and another important application of WMSN as drone, a means of strategic superiority and breaking capability to allow the monitoring and military intervention.

Figure 5. Flying A Predator From A Ground Station [26]

Figure 6. Drone Firing A Missile [27].

Geographic Information System (GIS) and tourism: A geographic information system is an information system designed to collect, store, process, analyze, manage and present all types of spatial and geographic data. The GIS acronym is sometimes used to define the “geographic information science” or “studies on geospatial information.” For example usage of WMSN in GIS is Google Earth is a program owned by the company Google, allowing capture and visualization of the Earth with a blend of aerial and satellite photographs. Several cities can be observed with sufficiently high resolution to be able to distinguish each individual building, house and even car

Figure 7. Composite Satellite Image Processed With Xplanet [31].

3. Basic Concepts

In this section we have given some basics on image compression as image consists of pixels that are highly correlated with each other. Correlation contains a large amount of redundancy that occupies the massive storage space and minimizes the transmission bandwidth.

3.1 General Principle of Image Compression

Compression of an image is usually done in the following block diagram in the figure 7.

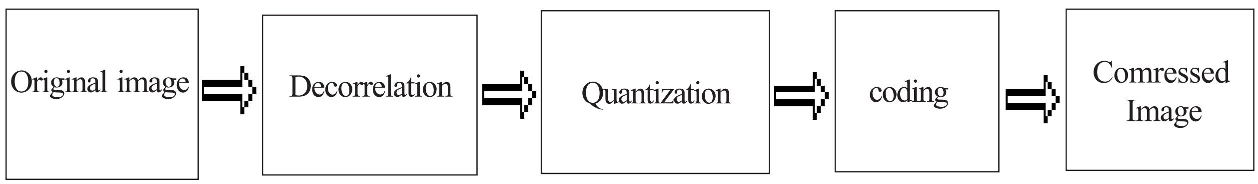


Figure 8. Block Diagram of Compression

Decorrelation Existing dependency between each pixel and its neighbors (the brightness varies little from one pixel to an adjacent pixel) indicate a strong correlation in the image. We therefore try to take advantage of this correlation to reduce the volume of information by performing a de-correlation operation of the pixels. De-correlation of transforming the original pixels in a set of coefficients less correlated, this is a reversible operation.

Quantization Quantizing the coefficients aims to reduce the number of bits needed for their representation. It represents a key stage of compression. It approximates each value of a signal by an integer multiple of a quantity q, called elementary quantum or quantization. It can be scalar or vector.

Coding Once the quantized coefficients, they are coded. An encoder must meet the following conditions priori. Uniqueness, two different messages should not be coded in the same facing. Decipherable, two successive code words must be distinguished unambiguously.

3.2 Performance measures of image compression

Compression methods can be classified into compression techniques with and without losses, which it’s detailed in *section* IV.B.1.

The image compression performance measures [1,6-8] are detailed in Figure 9.

In WMSN, the compression efficiency depends on the compression ratio that can judge the best compression. Compression speed is influenced by computational complexity and size of memory. Image quality, while MSE converge to zero is said that the compressed image is closer to the original image, and PSNR is most commonly used to measure the quality of reconstruction of lossy compression techniques. The signal in this case is the original data, and the noise is the error introduced by compression. When comparing compression techniques, PSNR is an approximation to human perception of reconstruction quality. Although a higher PSNR generally indicates that the reconstruction is of higher quality. Speed of compression, based on two main factors, computational complexity and memory resources, algorithmic efficiency are the properties of an algorithm which relate to the amount of resources used by the algorithm. An algorithm must be analyzed to determine its resource usage, for maximum efficiency we wish to minimize resource usage.

For this one has to be to make a comparison of WMSN and WSN scalar. The differences between WMSN and WSN scalar are summarized in the table I:

4.The image compression methods in wireless Multimedia Sensor Networks

4.1 Related Work.

Several research studies related to image compression in wireless multimedia sensor networks in the literatures [1] and [6-10].

In [1], ZainEldin H and al. discussed various compression techniques to WMSN a comparison between them and the factors that affect compression performance. Image quality, compression ratio, speed compression and power consumption are the most important indicators discussed for compression performance. They said SPIHT is the most powerful technique that can be used for the following reasons: reached SPIHT bit stream output very compact and low bit rate with a high compression ratio. They said Adaptation SPIHT for WMSN to reduce memory requirements is a future area attractive research.

In [6], Kumar v and al analyzes of all the obtained experimental results demonstrates that the incorporation of SVD and BTC in image compression along with OCT in an adaptive manner enhances the compression performance significantly.

They proposed technique performs the best technique in terms of PSNR and MSE. But it requires slightly longer time that makesit suitable for large bandwidth. This compression technique depends on the parameter (x) that based on the observation of the standard deviation (s) to decide what compression technique can be used as following: if (s< x) use DCT, else if (s > x) use SVD, else if (35 £ s £) use BTC

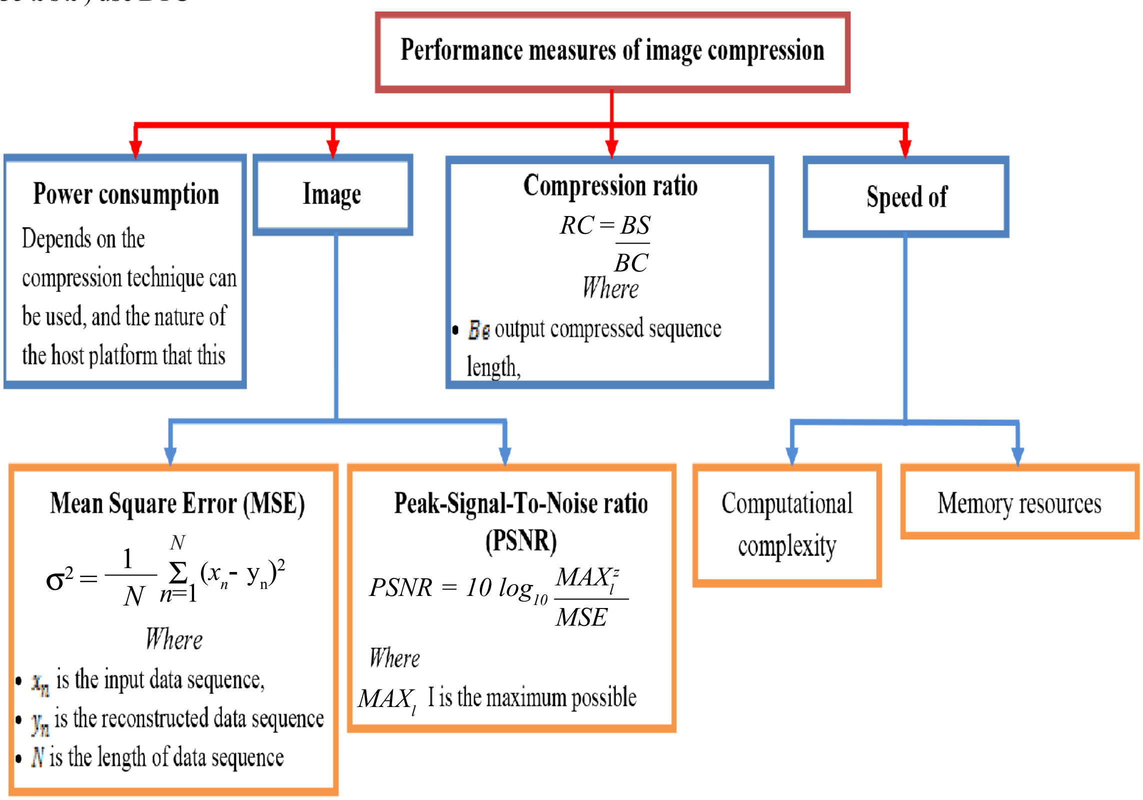


Figure 9. Performance measures of image compression

Factors	WMSN	WSN scalar
Transmission speed	low	lower
Energy consumption	higher	high
Memory (RAM)	limited	limited

Table 1. Comparison Between WMSN and WSN Scalar

in [7], GHORBEL O and al, proposed and evaluated two image compression methods dedicated to transmission over Wireless Sensor Networks (WSNs) in order to decrease the energy consumption of sensors and thus to maintain a long network lifetime. Image compression techniques which are based on the discrete wavelet transform (DWT) have been widely recognized over the other techniques. This is due to the wavelets excellent in terms frequency spread, spatial localization, and multi resolution characteristics, which almost are similar to the theoretical models of the human visual system.

IN [8], DAHMANI A and LOUCHENET A Presented Is An Improvement Of The Method that has already developed on their previous research [9] and is based only on the DCT. They have developed a hybrid method based on the use of two transforms DWT and DCT. The brand's recovery is done without the original image. The results of the previous section, they can see the performance obtained by the method developed in terms vis-à-vis robustness JPEG compression and the addition of Gaussian noise. This method is also robust to changes in formats and conversion of the marked image to grayscale. The constraint invisibility of the brand has been verified, because on one hand they have chosen to work on the middle frequencies of the low frequency sub-band (LL) and secondly the labeling chosen strategy ensures that the amendments made to DCT coefficients does not affect the contributions of these factors to the entire luminance of the block to which they belong.However, the proposed method can be improved, for example using the DWT at several levels, inserting a mark as a binary image and extension to other attacks.

In [10], Ma Tao and al, discussed JPEG techniques (DCT), JPEG2000 (EBCOT) and SPIHT and realize a comparison based on the factors compression rate, memory requirement and computational complexity, and after their synthesis according to these factors they said SPIHT is the best.

4.2 Description of compression methods

There are two types of methods for image compression lossy and lossless, In WMSN, we interested by lossy methods (Transform-based) because, after studies and syntheses realized by various researchers as [1][7][10][27][29], where they said transform-based techniques are better than non-transform based techniques, in terms of memory requirements complexity of the algorithm , processing speed, compression ratio, power consumption, and reconstructed picture quality.

Memory requirements, complexity of the algorithm and processing speed, there is a relation between these three factors that is to say, as the algorithm is simple, automatically the speed of fast processing and release of memory.

There are another relation between the compression ratio and the energy consumption. As the compression ratio is higher, increasing the operational life of WMSN.

4.2.1 Lossy compression methods

Lossy is the class of data coding methods using inaccurate approximations (or partial data rejection) to represent the content that has been encoded. Such compression techniques are used to reduce the amount of data that is necessary to store, process and / or transmit the content represented. The amount of possible reduction using a lossy data can often be much more important than what is possible with compression techniques of data without loss.The methods lossy used in WMSN (limited resources applications and low bandwidth) are classified into two categories,

1) Transform-based and 2) Non-transform based as shown in Figure. 4. [1][12-19]

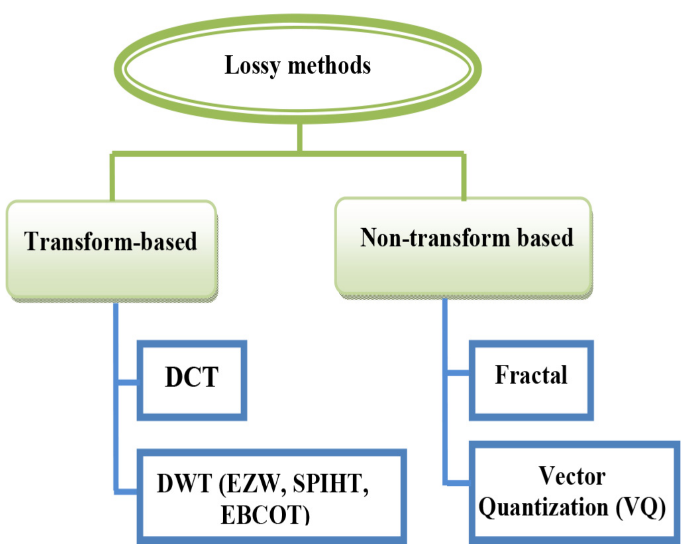


Figure 10. Classification of Lossy Methods

Discrete Cosine Transformation (DCT) [14-15] is a powerful mathematical tool that took its place in many compression standards such as JPEG and MPEG

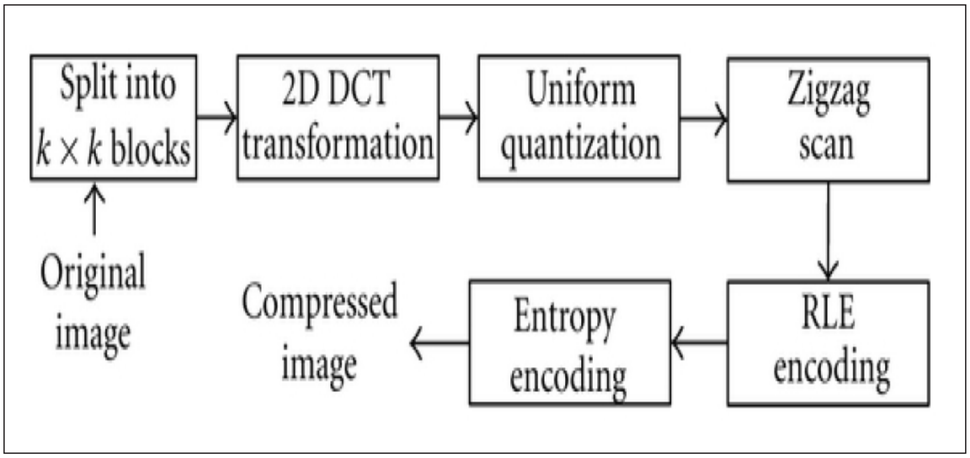
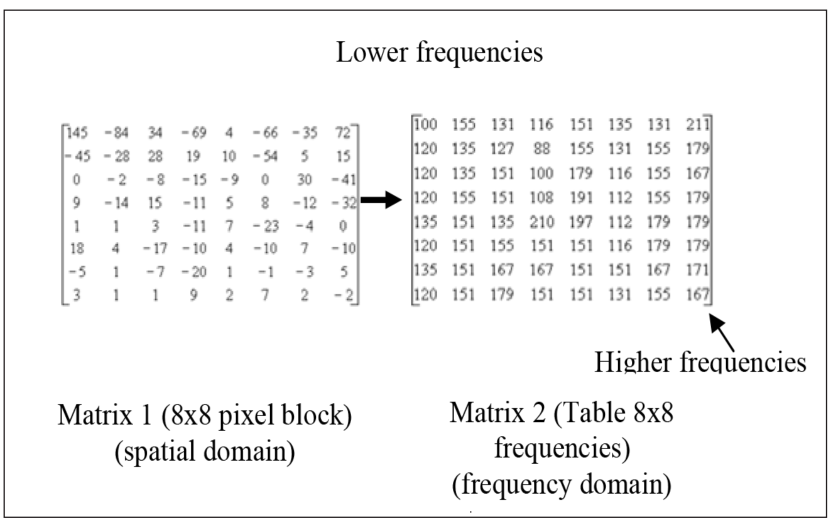


Figure 11. Lossy JPEG Compression Scheme. [29]

In the most general form, DCT can be expressed as matrix multiplication. The mathematical definition of 8 by 8 DCT matrix is given as follows:

$$DCT(t,f) = \frac{1}{\sqrt{2N}} c\,(i)\, c\,(j) \sum_{x=0}^{N-1} \sum_{x=0}^{N-1} pixel(x,y)\, cos\left[\frac{(2x+1)i\,\pi}{2N}\right] cos\left[\frac{(2x+1)j\,\pi}{2N}\right]$$

$$\text{where } c\,(x) = \frac{1}{\sqrt{2N}} \; if\, x = 0,\, and\ 1\ if\, x > 0$$



As Basses frequencies, uniform color range and High frequencies, sudden changes of color from one pixel to another.

Spiht [18]: This method deserves special attention because it provides the following, good high PSNR,image quality, especially for color images; it is optimized for progressive image transmission; produces a fully embedded coded file; simple quantization algorithm; fast coding/decoding (almost symmetric); has wide applications, completely adaptive; can code to exact bit rate or distortion; efficient combination with error protection.SPIHT is a wavelet-based image compression coder, is a method of coding and decoding the wavelet transform of an image. By coding and transmitting information about the wavelet coefficients, it is possible for a decoder to perform an inverse transformation on the wavelet and reconstruct the original image. The entirewavelet transform does not need to be transmitted in order to recover the image. Instead, as the decoder receives more information about the original wavelet transform, the inverse-transformation will yield a better quality reconstruction (i.e. PSNR) of the original image. SPIHT generates excellent image quality and performance due to several properties of the coding algorithm. They are partial ordering by coefficient value, taking advantage of redundancies between different wavelet scales and transmitting data in bit plane order following a wavelet transformation, SPIHT divides the wavelet into Spatial Orientation Trees. Each node in the tree corresponds to an individual pixel. The offspring of a pixel are the four pixels in the same spatial location of the same subband at the next finer scale of the wavelet. Pixels at the finest scale of the wavelet are the leaves of the tree and have no children. Every pixel is part of a 2 x 2 block with its adjacent pixels. Blocks are a natural result of the hierarchical trees because every pixel in a block shares the same parent. Also, the upper left pixel of each 2 x 2 block at the root of the tree has no children since there only 3 subbands at each scale and not four. Figure 5 shows how the pyramid is defined. Arrows point to the offspring of an individual pixel, and the grayed blocks show all of the descendents for a specific pixel at every scale.

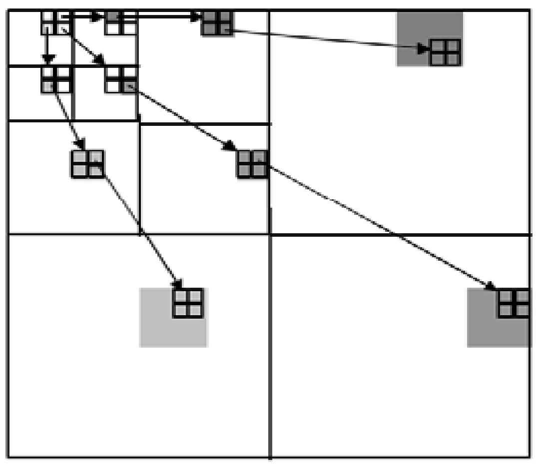


Figure 12. Hierarchical Trees In Multi-level Decomposition

EBCOT [19]: stands for Embedded Block Coding with Optimal Truncation; every subband is partitioned into little blocks (for example 64x64 o 32x32), called code-blocks. Every code-block is codified independently from the other ones thus producing an elementary embedded bit-stream. The algorithm can find some points of optimal truncation in order to minimize the distortion and support its scalability.

Table 2 [1] [12-19] provides a simple comparison of the three compression methods Lossy (Transform-based methods) DCT, SPIHT and EBCOT in terms of energy consumption, the quality of the output image (PSNR), the method of complexity, memory requirements, and the compression ratio (σ). In addition, it specifies the advantages / disadvantages of each method.

Performance Measures	DCT	SPIHT	EBCOT
Energy consumption	modest	low	high
Quality of the output image (PSNR)	low	high	high
Complexity method	low	modest	high
Memory Requirements	low	modest	high
Compression ratio ( )	low	high	high

Table 2. Comparison between Transform-based methods

5. Conclusion and Future Works

Image compression has become the recent years a topic of great interest. In WMSN given the severe limitations that contribute to apply on storage capacity, transmission and energy consumption, while resolution instruments continues to grow. The compression of the most efficient methods of image at present, are based on the wavelet transform, which allows to spatially decorrelate images.

Or, to be more efficient and exceed the compression rate limits achieved with the transformations (spatial decorrelators) Current (DCT, wavelets ...), it is necessary to develop "smart compressors" interested in content the image before the compression. In future works, the aim is to set up a new compression method applicable to 2D images in order to exploit the geometry of the image (the image content) to improve the compression quality report.

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