# "ANALYSIS OF IMAGE COMPRESSION ALGORITHMS IN WSN: A REVIEW"

Shwetha M[1], Ashwini.P[2], Sujatha B M[3]

*Absract:* **In the recent years, with the technological advancement in wireless communications and integrated digital circuits has lead to the exponential development of wireless sensor networks (WSNs) that has become dramatically feasible. WSN is a wireless network composed of large number spatially distributed small nodes with sensing, computation, and wireless communication capabilities. The various resource limitations of the sensor nodes that should be considered while transmitting or receiving the real time images over WSNs are memory, computing power, narrow bandwidth and Energy. In image based applications large volume of data needs to be transmitted which results in large energy consumption at the nodes forwarding data towards the sink node. Hence Image compression is the answer for transmission of image over WSNs. In this paper a review on six popular image compression algorithms such as DCT, DWT, JPEG,EZW,SPIHT, EBCOT is presented and it is found that SPIHT wavelet based image compression is more efficient due to high compression ratio and simple coding procedure.**

***Key words*: Wireless Sensor Network, DCT( Discrete Cosine Transform),DWT( Discrete Wavelet Transforms), EZW(Embedded zero tree wavelet-based image Coding),EBCOT( Embedded block coding with optimized truncation), SPIHT(set Partitioning in Hierarchical Trees).**

## I INTRODUCTION.

### A. *Image compression algorithms*

There are two classes of data compression techniques.

1. Lossy compression.
2. Lossless compression.

In lossy compression some details of image information will be lost but still the vital information of the image is preserved and the image quality is in acceptable range. The main goal of lossy compression is to remove redundancy and some details that are not vital to the image and reduce the amount of data storage while preserving the quality of the image. The data compression techniques often are applied on the sound and images that have some redundancy that can be removed to reduce the size of audio and video information before transmission on any networks. In the second class of compression, lossless compression, the detail of information is important and we would like to preserve all details and vital information while reducing the size of image or sound files for the storage reduction. Hence the lossless data compression techniques is more suitable for text and file compression. There are many applications that use lossy data compression techniques to reduce the data redundancy and improve their efficiency by reducing data storage and processing time.

In this section, a literature review on image compression algorithms – DCT, DWT Joint Photographic Experts Group (JPEG), Embedded Zerotree Wavelet (EZW), Set-Partitioning in Hierarchical Trees (SPIHT) and Embedded Block Coding with Optimized Truncation (EBCOT) algorithms are described

#### *A.A Discrete cosine transform based image compression.[1]*

In DCT based image compression, the source image is first partitioned into sub-images in the form of blocks with a typical block size of 8 x 8 pixels and coding of each image block is done independently. DCT causes no loss to the original image data as it merely transforms the image into a domain in which they can be encoded more efficiently [12]. After the discrete cosine transformation, each of the 64 DCT coefficients is uniformly quantized. Zig-zag scanning is then applied to rearrange the coefficients prior to entropy coding. The low frequency non-zero components are placed at the beginning of the bit stream followed by the high frequency components[1]. Figure 1 shows the process of zig-zag scanning. The DC component which contains important information about the image is coded differently. Finally, the output stream after the zig-zag scanning is entropy encoded.

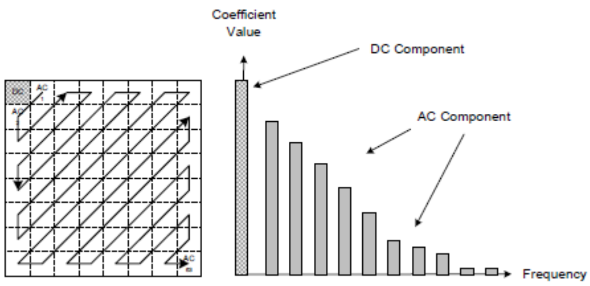


Figure 1. Zig-zag scanning

DCT-based image compression provides satisfactory compression efficiency and it gives a low memory implementation since the encoding is done on small individual image blocks [13]. However, the tiling of the blocks causes blocking artifacts which lead to a degradation in performance especially at very low bit rates [13] [12].

#### *A.B Discrete wavelet transform (DWT)*

Wavelets are signals which are generally irregular in shape and local in time and scale. A wavelet is a waveform that has an average value of zero and effectively limited duration. The DWT represents an image as a sum of these wavelet functions, with different location and scale [7]. In DWT technique the image data is divided in to a set of high pass coefficients (detail) and low pass coefficients(approximate)[3]. In DWT the image is firstly divided into a set of 32×32 blocks and then each block is passed through the two filters: In the first level decomposition the input image is divided in to four multiresolution non- overlapping sub-bands LL,HH,LH, and HL which are also called as coefficients. The sub-band LL also called as approximation coefficient represents coarse-scale DWT coefficients and the sub-bands LH,HL, and HH are also called as detailed coefficients which represents the fine-scale of DWT coefficients. The LL coefficients are transformed into the second level by discarding all the detail coefficients. To achieve the required compression ratio the LL coefficients are passed through a constant scaling factor. As illustrated in the Fig. 2. The input signal, the high frequency components and the low frequency component are denoted by x[n], d[n] and a[n] respectively. For reconstructing the coefficients are rescaled followed by padding zeros and then passed through wavelet filter.

In case of DWT image is not divided in to non-overlapping 2D-blocks and as the transformation is applied on the whole image, it avoids blocking arifacts and results in higher compression ratio as compared to DCT.

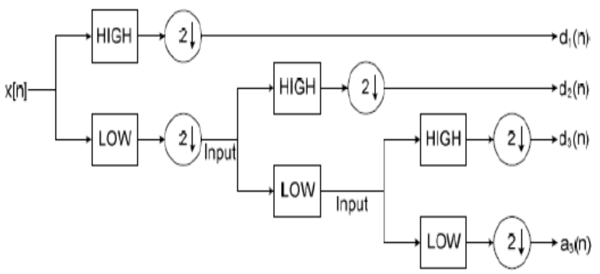


Fig 2: Block diagram of the 2 level DWT Scheme.

*A.C JPEG : DCT-Based Image Coding technique.*

JPEG is one of the lossy compression algorithm. Discrete Cosine Transform (DCT) is a basis for the JPEG algorithm. Now a days the still image compression using JPEG/DCT has become a standard [2]. JPEG is designed for compressing natural, real-world scenes images in the form of full-color or gray scale. In this method, firstly the image is divided in to non overlapping 8X8 blocks and a Cosine transform (DCT) [10,14] is applied on each block to convert the gray scale levels of pixels which are in spatial domain into coefficients in frequency domain. These coefficients are quantised using a quantization table which is provided by JPEG standard conducted by some psycho visual evidence. In turn these quantised coefficients are of two types DC coefficients and AC coefficients. DC coefficient is encoded using difference encoding technique and the AC coefficients are scanned in a zig-zag fashion so that the 8X8 DCT coefficients are scanned in an increasing order of spatial frequencies. These quantised and Zig-Zagly rearranged coefficients are further compressed using lossless coding techniques such as arithmetic coding, run length coding or Huffman coding as shown in Fig.3[17]. The decoding process is an inverse process of encoding. Hence the time taken for both encoding and decoding is same in case of JPEG compression

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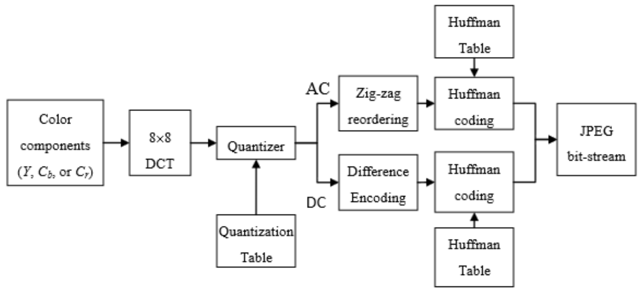


Fig 3: Baseline JPEG encoder.

Some amount of information loss occurs during the process of coefficient quantization. In a JPEG standard for all images a standard 8×8 quantization table [9] is defined which may not be appropriate. Instead of using the standard quantization table an adaptive quantization table may be used in order to achieve a better decoding quality of an image by using same compression with DCT approach. At low compression rates DWT provides lower quality than JPEG. In JPEG 2000 standard DWT is used as basis for transformation[18].

*A.D Embedded zerotree wavelet-based image coding.*

The embedded zerotree wavelet algorithm (EZW) is an effective image compression algorithm. With the introduction of popular wavelet-based image coding technique Embedded coding started to gain attention in the field of image coding EZW [6]. EZW coding involves the coding of the position of those wavelet coefficients that will be transmitted as a non-zero value. A wavelet coefficient, x is said to be insignificant or significant with respect to a given threshold T. If $|x| < T$. However, the coefficient is said to be significant with respect to T if $|x| \geqslant T$. The algorithm is developed based on the following hypothesis quoted from [6] - "if a wavelet coefficient at a higher scale is insignificant with respect to a given threshold T, then all the wavelet coefficients corresponding to same spatial location at the lower scales of similar orientation are likely to be insignificant with respect to T." In EZW to represent a tree node it uses four symbols: ZTR (zerotree root), POS (positive significant), NEG (negative significant), IZ (isolated zero node) and instead of 0 and 1. In EZW coding, a tree is referred to as the zerotree if the parent node and all its descendants are insignificant with respect to the threshold. For a threshold T if the coefficient is not the part of a previously found ZTR starting at a coarser scale for that threshold T then it is coded as zerotree root (ZTR).However, if the coefficient is insignificant with respect to threshold T but has some significant descendants, it is coded as isolated zero (IZ). Depending on the sign of the coefficient[1] which is found to be significant with respect to T, is coded as positive significant (POS) or negative significant (NEG) .

*A.E Set-Partitioning In Hierarchical Trees Image Coding.*

SPIHT is one of the wavelet-based image compression coder. Firstly it converts the image into its wavelet transform followed by the transmission of information about the wavelet coefficients. After wavelet transformation, SPIHT divides the wavelet coefficients into Spatial Orientation Trees [19]. Each node in the tree represents an individual pixel. The four pixels of the same subband in the same spatial location at the next finer scale of the wavelet are the offspring of these pixel. Every pixel is a part of 2X2 block along with its adjacent pixels. As every pixel in a block shares the same parent blocks represents the hierarchical tree. In every 2X2 block the upper left pixel at the root of the tree has no children. Fig. 4[19]. represents the spatial tree orientation. The arrow points to the offspring of each individual pixel and the gray colored block represents the descendents of a specific pixel at every scale.

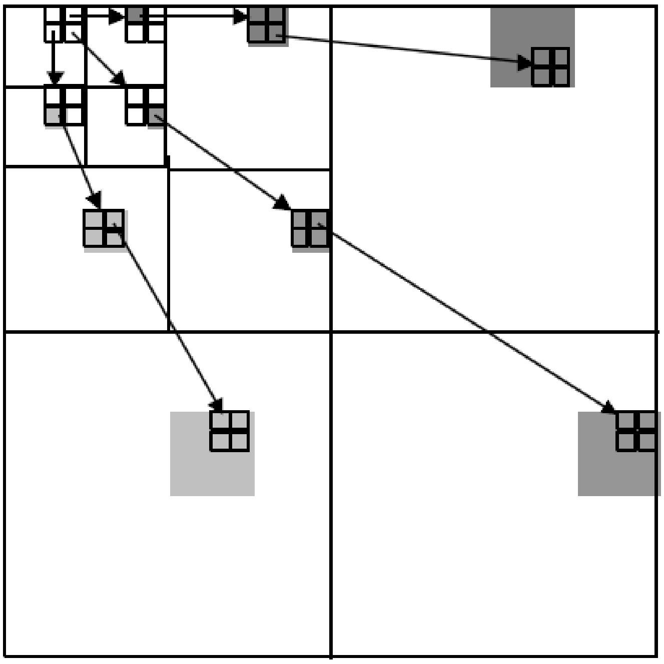

Fig. 4 Spatial tree orientation.

SPIHT [7] coding adopts a set-partitioning approach where the significance test result is binary. A coefficient is encoded as significant i.e. Sn(i, j) = 1 if its value is larger than or equal to the threshold T. If the coefficient value is smaller than T, then it is coded as insignificant i.e Sn(i, j) = 0. Also, in the SPIHT algorithm there are two types of descendant trees :

Type A or D(i, j) set which contains all the descendants of node (i, j).

Type B or L(i, j) set which contains all the grand descendants of node (i, j).

Also there are two coding passes in SPIHT algorithm,

1. Sorting pass.
2. Refinement pass.

During the sorting pass, based on the order in which the coefficients are stored in the List of Insignificant Pixels (LIP) a significant test is performed. Elements in LIP which are found to be significant with respect to the threshold are moved to the List of Significant Pixels (LSP) list followed by significance test. Significance test is performed for the sets in the List of Insignificant Sets (LIS), if any of the set in LIS is found to be significant, then the it is removed from the LIS and is divided in to a new subset and four single elements. So formed new subset is added back to LIS and depending on whether the four newly formed elements are insignificant or significant with respect to the threshold, they are moved to LSP or LIP.

During the second coding pass, refinement is carried on every individual coefficient that are added to the List of Significant Pixels (LSP) except for those elements that are newly added during the first coding pass that is sorting pass. Refinement is carried out on each of the coefficients of the list to an additional bit of precision. Finally, SPIHT coding is repeated by dividing the threshold by 2, until the target is met or all the coefficients are coded.

*A.F Embedded block coding with optimized Truncation..[11]*

Similar to other image compression algorithms such as EZW and SPIHT, EBCOT also uses the wavelet transformation for dividing the energy of the original image into subbands which are then quantized and coded. In EBCOT, each individual subband is divided in to a relatively small blocks of samples which are called as code-blocks. The EBCOT is a two-tiered algorithm consisting of two coding steps: Tier-1 and Tier-2 which are also called as embedded block coding and Organization of the bit-stream respectively. Tier-1 is further divided into two sub-modules: 1.Bit-plane coder (BPC)

2.Binary arithmetic coder (BAC).

EBCOT encodes each bit-plane in the three coding passes. 1. significant propagation 2. magnitude refinement pass 3. cleanup pass followed by sending the associated Context to the arithmetic coder (MQ coder) as shown in Fig:5 and the coded data are then formatted using the standard (code stream syntax) to form the final bit stream. To construct the context information which consists of context (CX) and decision (D), the BPC uses the neighbouring information of a current bit.

which will be followed by an entropy encoding by BAC. BAC becomes the bottleneck for the throughput of the encoding system as it is inherently dependent on the arithmetic operations and control statements which in turn causes the timing limitation.

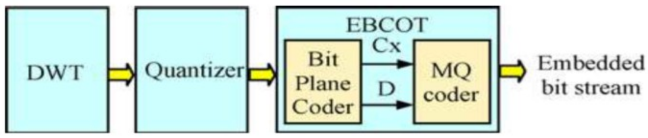


Fig 5: Overview of EBCOT

## II OBSERVATION AND ANALYSIS

Table I shows a comparison between DWT and DCT with the evaluation criteria terms: Compression Performance, Execution Time and used Memory. Character (+) refers the quality and performance task. When the number of (+) increases, it means that the operation is successfully used by this algorithm and gives good results[16]. Table II summarizes the properties and characteristics of the JPEG, EZW, SPIHT and EBCOT image compression algorithms presented in this paper. The purpose of this analysis is to find the most suitable image compression algorithm for implementation in a wireless sensor network. Image compression algorithms which are based on the discrete wavelet transform (DWT) have been widely recognized to be more prevalent than DCT. This is due to the wavelets' excellent spatial localization, frequency spread, and multiresolution characteristics,[5] and DWT is efficient than DCT due to the presence of blocking artifacts in DCT which results in reduction in the quality of the reconstructed image. In wavelet image transform the computation energy can be reduced by skipping the computation of the small high pass coefficients which is known as SHPS (Skipped High Pass Sub-band)[4]. SPIHT image coding generates bit streams according to the order of importance based on the embedded properties that EZW coding possesses, it also gives a better performance than EZW [7]. Though the compression efficiency of EBCOT coding is higher than SPIHT, but it needs multiple coding table and multilayered coding procedures which makes them very complex, expensive and also it requires extra memory allocation[14][15].

| Efficiency Criterion | *DCT* | *DWT* |
|---|---|---|
| *Compression performance* | +++ | +++++ |
| *Execution Time* | + | +++ |
| *Memory Used* | +++ | + |

Table I: Comparative criterion between DWT and DCT

| Characteristics | Compression algorithms | | | |
|---|---|---|---|---|
| | JPEG | EZW | SPIHT | EBCOT |
| Transformation | DCT | DWT | DWT | DWT |
| Coding Table | No | No | No | Yes |
| Entropy coding | Arithmetic Coding | Arithmetic Coding | Not needed | Arithmetic Coding |
| Memory Requirement | Low | Average | Average | High |
| Computation Load | Low | Low | Low | High |
| System Complexity | Low | Average | Average | High |
| Coding Speed | High | High | High | Average |
| Compression Quality | Low | Average | High | High |
| Most Suitable for WSN | | | √ | |

Table II: Summary of Analysis

## III CONCLUSION

In this paper various image compression algorithms are analysed and found that DWT is efficient than DCT due to the presence of blocking artifacts in DCT. SPIHT image coding better performance than EZW [7]. Though the compression efficiency of EBCOT coding is higher than SPIHT, but it needs multiple coding table and multilayered coding procedures which makes them very complex Based on the results of the evaluation conducted on the six popular image compression algorithms it is found that SPIHT with DWT based image compression is most suitable image compression algorithm for implementation in WSN.[1]. In the future energy efficient SHPS algorithm can be combined with the SPIHT algorithm to enhance the image quality further.

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**Shwetha M**, M.Tech( DCE), Acharya Institute of Technology, Bangalore, India,
**Ashwini P**, M.Tech( DCE), Acharya Institute of Technology, Bangalore, India[2]
**Sujatha B M**, Associate Professor, Dept of E&C, Acharya Institute of Technology, Bangalore, India[3]


  