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Performance analysis of image compression using multiple description coding based on set partitioning in hierarchical tree

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ABSTRACT
This paper presents a multiple description coding method for HD image. The proposed method is bases on the SPIHT algorithm which provides high image compression ratio. The algorithm based on wavelet transforms and Wavelet-based compression provides multi-resolution hierarchical characteristics. This proposed method also uses poly phase sampling technique to generate multiple descriptions. The technique reduces the transmission error and memory required for storing HD images. The proposed method proved higher performances in terms of PSNR when compared to the standard SPIHT. The graph of PSNR versus BER is given in the experimental results.

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Introduction

Image compression is used to reduce irrelevance and redundancy of the image data to be able to store or transmit data in a competent form. Image compression can be classified into two types lossy or lossless. Lossless compression is useful in preserving information and preferred for archival purposes and often for medical imaging, technical drawings, clip art, or comics. Lossy compression methods used at low bit rates, introduce compression artifacts. Lossy methods are particularly suitable for natural images for example photographs in applications where minor loss of fidelity is acceptable to attain a considerable reduction in bit rate. It is possible to compress many types of digital data in a way that moderates the size of a computer file needed to store it, or the bandwidth needed to stream it, with no loss of the full information contained in the original file. The original file contains a certain amount of information. The data storing in an organization or in medical is also a problem that is more and more data can be transmit and store by a minimum cost of memory. Due to arising demands of network applications, more memory required for transmitting and storing data, unstable network and data losses causes severe problems in transmission.

This proposed method is simple and efficient, and has features of simplicity, efficiency and flexibility. An image coding method which provides good performance under congested network environment is very essential. In this paper, MDC is used for HD image because MDC provides a set of descriptions and all the descriptions are independently coded with the same and different data size in the coding processes. The data can be transmitted in more than one time by different processes. MDC usually provides to graceful degradation and does not require any transmission. MDC is more preferable than the layer coding method. In MDC, if more descriptions are received, the quality of image will improved. It can perfectly reconstruct the original image when all the descriptions are received.

There are three popular algorithms for Data compression based on wavelet transform i.e. Embedded Zero-tree Wavelet (EZW), Embedded Block Coding with Optimized Truncation (EBCOT), and Set Partitioning in Hierarchical Trees (SPIHT) [1]. In these three algorithms, the SPIHT algorithm is used because of its better efficiency and high compression performance. The ordering of the bit streams from more significant to less significant is the main feature of the SPIHT. In SPIHT coding, the front part of the bit stream has important data than the rear part so that it is transmitted first. The decoder gets the data and decodes the front data first. So, when congestion takes place, keeping the front part of the bit streams can preserve the important data. So that, it can improve and provides the better transmission performance under the unstable network where the congestion occurred or error rate is high. That is why the SPIHT is mostly used as compare to other coding method and it has the higher capability to contend against package losses.

In this paper, a new multiple description method is developed. This new method has improved result in quality of construction image at low bit rate and also provides a very flexible and convenient frame work to have an arbitrary number of descriptions which tackle the limitation of having less number of descriptions in the existing MDC schemes [3] [7] and process these descriptions in different stage of coder. This method gives a good quality image of gray-level images.

Multiple description coding

In MDC, a source is divided into some simultaneous bit streams called descriptions and these descriptions, are then transmitted separately, possibly through different network paths. In MDC, as long as one or more descriptions arrive at the receiver. When more descriptions are received, the higher quality image can be completed. If a packet is lost, the corresponding packets of the other descriptions, containing a different representation of the data in the lost packet, may be available and the image is decoded successfully but with a lower reliability.

Multiple Description image coding is capable in unreliable transmission because there are correlations between descriptions and the lost descriptions can be assessed by the receiver. It promises that the MDC reaches a suitable quality when it

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receives one description only. MDC can generate more than two descriptions via a specific coding scheme. A MDC scheme does not require retransmission when package losses occur unless the losing rate is extremely high. That is why the MDC is so popular. Usually MDC is used for two applications: .real time communications and reducing the complex of network design. For real time communications, such as video phone or video conference, retransmission is not allowed in those applications. MDC doesn't need feedback and retransmission, and all the packages are equal.

Poly-phase sampling technique

Poly-phase sampling technique is an image transformation technique which transforms one image into four-based images. The simplest approach is to divide the image into multiple sub images and encode each one independently. Here, we take an example shown in figure is to transform one image into four images. In the figure, we take four pixels as a set, and mark them number 1 to number 4, respectively on every specific position and placing the pixels together which have the same number in the same frames [1]

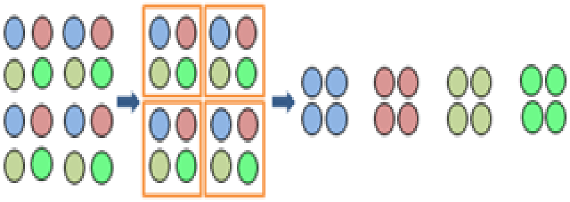


Figure 1. Four pictures after poly-phase sampling

Set partitioning in hierarchical trees

Set partitioning in hierarchical trees (SPIHT) is an image compressing algorithm. The algorithm uses a partitioning of the trees in a manner that tends to keep insignificant coefficients together in larger subsets [8].

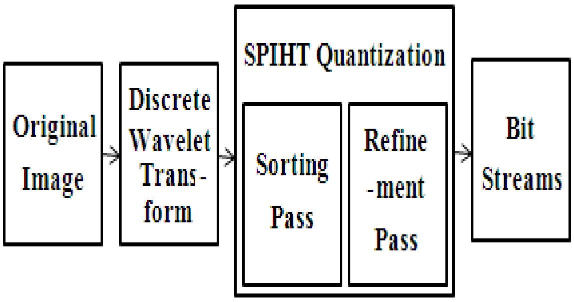
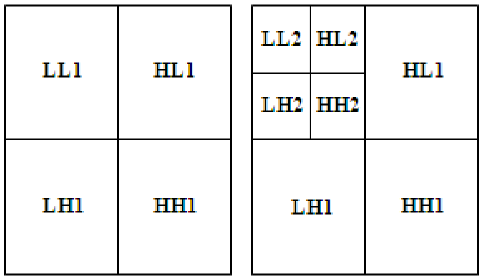


Figure 2. The coding process of SPIHT

Wavelet transform

The wavelet transform has considered as an important technique within the field of image analysis. Wavelets are a mathematical tool for hierarchically decomposing functions. Wavelet Image Processing facilitates computers to accumulate an image in many scales of resolutions, thus decomposing an image into various and types of details and approximation with different valued resolutions. Wavelets facilitate image compression using less storage space with more details of the image. Wavelet-based coding is more robust under transmission and decoding errors, and also allows progressive transmission of images.

At the first stage of wavelet transform, the original image is divided into four sub-bands. Each sub-band is further decomposed by separable vertical and horizontal filters. This process is continued till the final level is reached.



(a) One-Level (b) Two-Level

Figure 3. Image decomposition by using DWT

An original image decomposes into a hierarchy after multi-resolution wavelet transform containing one lowest resolution low-pass sub-image on the top layer and three high-pass sub-images on each layer. As we know that human visual system is more sensitive to low frequency components than to high frequency components. In a wavelet transform (as shown in figure) we call HL1, LH1, and HH1 the sub-bands resulting from the first level of the image decomposition, corresponding to horizontal, vertical and diagonal frequencies [3]. The rest of the transform is computed with a recursive wavelet decomposition on the remaining low frequency sub-bands, until a desired decomposition level (N) is achieved (LLN is the remaining low frequency sub-band), Wavelet transform de-correlates the image, but there still exists cross-correlation between different layers for the same orientation high-pass sub-images.

It is noticed that the same orientation sub-images on different layers have a similar structure. Although such dependency between different resolutions has been used earlier to compress images such as EZW and SPIHT etc. which are based on wavelet trees structure, The LTW enhances the performance significantly. Furthermore, the probability density function of wavelet coefficients is approximately a generalized Gaussian distribution. It is symmetric and has a peak value centered at zero. This implies that most of the coefficients will be around zero value and considered insignificant. A simple threshold can discard these insignificant coefficients and substantially reduce the computational complexity [4] [5].

Proposed method

In the proposed method, MDC has been studied as an approach for transmission of images over error prone environments. The MDC method for High Definition (HD) images proposed here takes into account the content of the image and provides the least amount of degradation, caused by loss of descriptors, for those areas of the images which are of greater interest. There are also some important issue such as coding efficiency, processing memory, coding complexity, bit rate scalability and error resistance.

The proposed research aims to develop an approach for MDC of HD images which improve the above mention issue related to it by using SPIHT wavelet based image compression algorithm. Fig. 4 shows the encoding block diagram of the proposed method. Firstly, we divide a HD image into four descriptions by using poly-phase sampling. Then each of them passes through the SPIHT algorithm in different ways as shown in fig. 4. After the poly-phase sampling, all the descriptions passes through SPIHT as LL band of all description named as D_{1LL} to D_{4LL} and the entire horizontal, vertical and diagonal tree as a separate descriptions as D_{1H} to D_{4H}, D_{1V} to D_{4V} and D_{1D} to D_{4D} respectively.

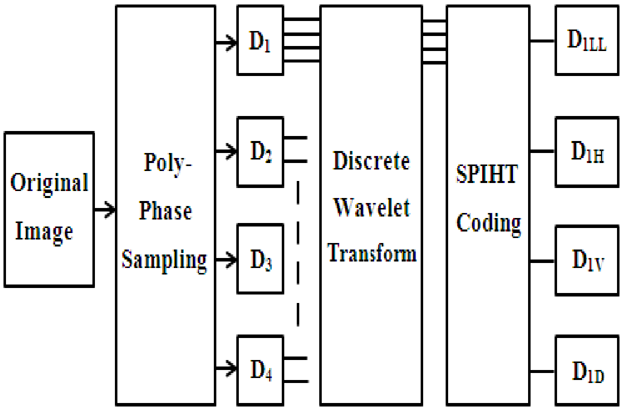


Figure 4. The block diagram of proposed method for encoding

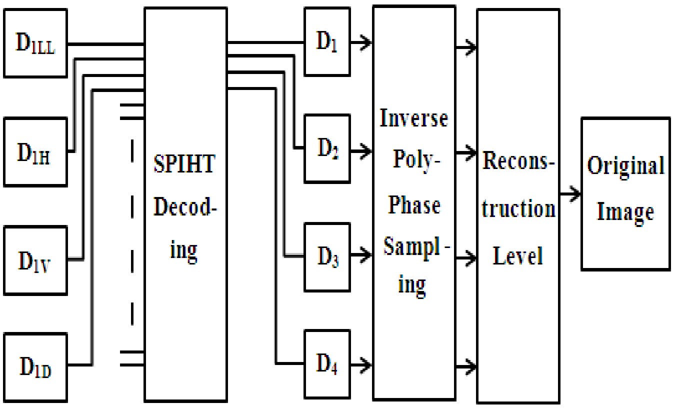


Figure 5. The block diagram of proposed method for decoding

Figure 5 shows the decoding block diagram of the proposed method. After receiving the descriptions as LL band of all description named as D_{1LL} to D_{4LL} and the entire horizontal, vertical and diagonal tree as a separate descriptions as D_{1H} to D_{4H}, D_{1V} to D_{4V} and D_{1D} to D_{4D}, the first step is to pass them through the SPIHT decoder and then passes through the inverse poly-phase sampling as shown in figure 6. The last step is to perform reconstruction, to fill in the lost information caused by package losses and to reconstruct the original image. The original image will be obtained as same quality level if sufficient descriptions will obtain correctly.

Reconstruction

Reconstruction is the last step of decoding side to fill up the losing pixels caused by package losses. Take Figure 6 as an example; assume that the brown pixel is the losing pixel. Reconstruction is obtained by taking average of 3 above pixels and filling in the losing pixel. This is a simple but an effective method.

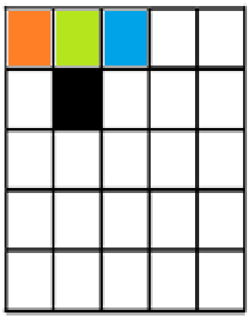


Figure 6. Reconstruction block diagram

Experimental Results

The experiment is carried out in MATLAB 7.9.0. The performance of the proposed approach is evaluated based on the PSNR value. The proposed technique is compared with the image compression using SPIHT algorithm based on wavelet transform. We consider the “Lena” image (512 x 512) which is monochrome pictures with 8 bpp (bits per pixel) before compression. The following results were obtained with 0.5 bpp (bits per pixel) and 5 levels of wavelet transform were performed. The characteristics of the proposed method will be illustrated using the tested image Lena as shown in Figure 7.

Table 1: PSNR (dB) at different BER for LENA

LENA IMAGE		
	Pro-SPIHT	**SPIHT**
BER	**PSNR (dB)**	**PSNR (dB)**
0	30.2702	36.5535
0.00001	30.1350	36.5534
0.0001	22.1214	25.9471
0.001	18.0126	13.1831
0.01	13.3233	10.6052
0.1	11.1888	7.7459

The graph of PSNR versus BER has been drawn with the help of data in the table 1 for LENA image and is shown below in fig. 7, which clearly shows the improvement in the PSNR for Proposed SPIHT as compared to SPIHT for the same BER.

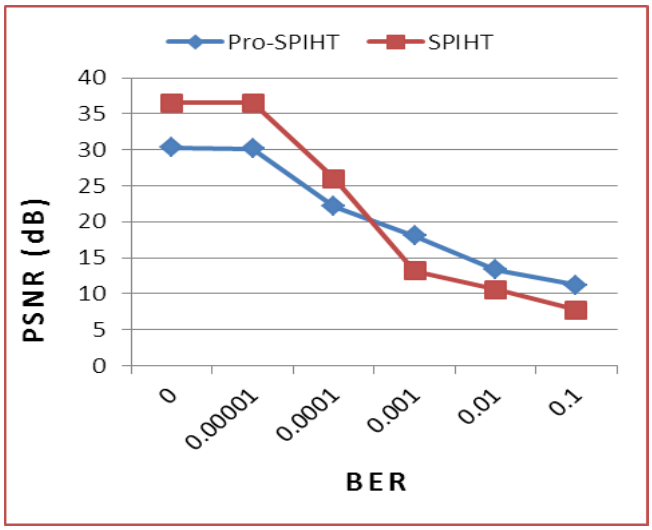


Figure 7. PSNR versus BER graph comparisons of SPIHT and Proposed-SPIHT for LENA Image

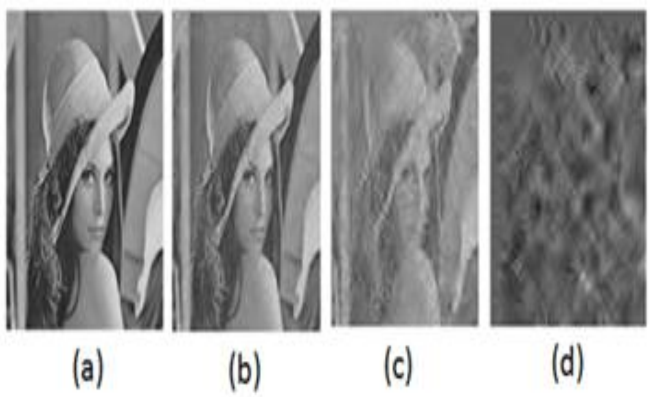


Figure 8. Original SPIHT (a) BER 0.00001 (b) BER 0.0001 (c) BER 0.001 (d) BER 0.01 Images

Figure 9. Proposed SPIHT (a) BER 0.00001 (b) BER 0.0001 (c) BER 0.001 (d) BER 0.01 Images

Conclusion

In this paper, the experimental results show that the proposed SPIHT algorithm has improved performance as compared to standard SPIHT. The PSNR versus BER graph of LENA Image clearly shows an improvement in PSNR up to limited dB for the Lena image. So the compression is achieved with a good compression ratio and compression factor. Here also we see that the processing time is decreases as compare to the original SPIHT algorithm.

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