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Arithmetic Coder Architecture used in SPIHT image compression

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Abstract: A Memory-efficient high throughput architecture of arithmetic coder for the set partitioning in hierarchical trees (SPIHT) image compression is proposed in this paper. In this architecture optimizations at different levels of arithmetic coding gives good image compression with high PSNR.

Keywords: Arithmetic coding, Peak Signal to Noise ratio (PSNR), Set Partitioning in Hierarchical Trees (SPIHT), VLSI Arithmetic coder architecture, Wavelet.

I. INTRODUCTION

Set Partitioning in Hierarchical Trees (SPIHT) is a wavelet-based image compression coder that offers a variety of good characteristics. These characteristics include:

- Good image quality with a high PSNR
- Fast coding and decoding
- A fully progressive bit-stream
- Can be used for lossless compression
- Ability to code for exact bit rate or PSNR

The main advantage of SPIHT is its fully progressive behaviour, means it does not need whole file to see the image. The image's PSNR will be directly related to the amount of the file received from the transmitter. This means that our image quality will only increase with the percentage of the file received. After the SPIHT transformation, some regularities will exist in the file. These regularities may allow us to further compress the file. With this in mind we investigated the addition of arithmetic compression to a SPIHT encoded image. A few different code implementations are presented here and the compression results are compared.

II. OVERVIEW OF ARITHMETIC CODING

Arithmetic coding is a well-known method for lossless data compression. Arithmetic coding is a compression technique that can give compression levels at or very near entropy. What this means is that if we have a message composed of symbols over some finite alphabet, we can generate the exact number of bits that corresponds to a symbol (e.g. 1.6 bits/symbol). This is opposed to Huffman encoding which must output an integer number of bits per symbol (e.g. 2 bits/symbol).Arithmetic coding achieves entropy (or very near it) by grouping symbols together until an integer value of bits can be outputted for a sequence of symbols (e.g. ABC may correspond to 1011).

Arithmetic coding works by using a probability interval defined with variables L and R, which are initially set to 0 and 1 respectively. The value of L represents the smallest binary value consistent with a code representing the symbols processed so far.

The value of R represents the product of the probabilities of those symbols. To encode the next symbol, which is the j^{th} of the alphabet, both L and R must be recomputed. L and R get the following values:

$$L = L + R \times \sum_{i=1}^{j-1} p_i$$

$$R = R \times p_i$$

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III. RELEVANCE

As arithmetic coding (AC) method can obtain optimal performance for its ability to generate codes with fractional bits, it is widely used by various image compression algorithms. Especially, the set partitioning in hierarchical trees (SPIHT) uses an AC method to improve its peak signal-to-noise ratio (PSNR). Although the theory and program code of AC are mature, the complicated internal operations of AC limit its application for some real time fields, such as satellite image and high speed camera image compressions. In order to achieve performance gains, high speed architecture of AC in compression scenarios must be designed to meet the throughput requirement.

IV. LITERATURE REVIEW

D. Marpe, H. Schwarz, and T. Wiegand presented Context-Based Adaptive Binary Arithmetic Coding (CABAC) as a normative part of the new ITU-T/ISO/IEC standard H.264/AVC for video compression [2]. By combining an adaptive binary arithmetic coding technique with context modelling, a high degree of adaptation and redundancy reduction is achieved. The CABAC framework also includes a novel low-complexity method for binary arithmetic coding and probability estimation that is well suited for efficient hardware and software implementations.

A Variant of SPIHT image compression algorithm called No List SPIHT (NLS) is presented by F. W. Wheeler and W. A. Pearlman [3]. NLS operates without linked lists and is suitable for a fast, simple hardware implementation. Instead of Lists, a state table with four bits per coefficient keeps track of the set partitions and what information has been encoded. Performance of the algorithm on standard test images is nearly the same as in SPIHT.

H. Pan, W.C. Siu, and N.F. Law, proposed A fast and low memory image coding algorithm based on lifting wavelet transform and modified SPIHT [5]. In this paper, Author propose a listless modified SPIHT (LMSPIHT) approach, which is a fast and low memory image coding algorithm based on the lifting wavelet transform. The LMSPIHT jointly considers the advantages of progressive transmission, spatial scalability, and incorporates human visual system (HVS) characteristics in the coding scheme; thus it outperforms the traditional SPIHT algorithm at low bit rate coding. Compared with the SPIHT algorithm, LMSPIHT provides a better compression performance and a superior perceptual performance with low coding complexity. A listless implementation structure reduces the amount of memory and improves the speed of compression by more than 51% for a 512×512 image, as compared with that of the SPIHT algorithm.

Authors A. A. Kassim, N. Yan, and D. Zonoobi presented [6] the wavelet-based set partitioning in hierarchical trees (SPIHT) which is highly efficient in coding non textured images while the wavelet packet transform (WPT) is able to provide an optimal representation for textured images.
Authors introduce a method for selecting an optimal WPT basis for SPIHT, which efficiently compacts the high-frequency sub-band energy into as few trees as possible and avoids parental conflicts. The proposed SPIHT-WPT coder achieves improved coding gains, especially for highly textured images.

V. METHODOLOGY

- High resolution Image captured using Camera.
- Input image is converted to pixel values in MATLAB. Pixel values obtained are given as input to the Line based wavelet lifting module which produces wavelet coefficients.
- The transformed wavelet coefficients are placed in a buffer and they are accessed in a SPIHT-Breadth First Search way. Processor dispatcher dispatches the transformed wavelet coefficients to the arithmetic coder through internal bus.
- Output of arithmetic coder is provided to the internal bus and sent to the code FIFO.
- The Read FIFO and Truncate module are responsible for the final code stream formation, which reads each code FIFO from top to bottom and truncates the code stream according to the bit rate requirement.

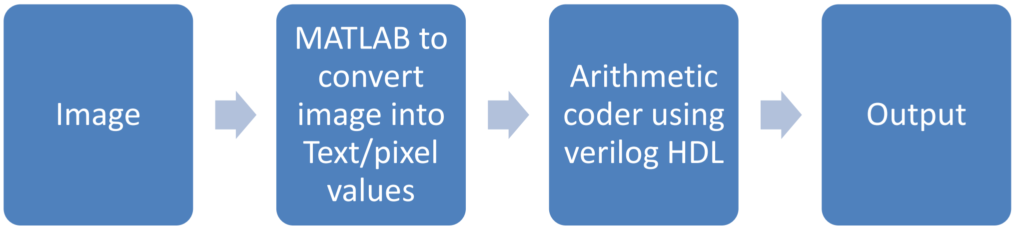

Fig.1 Block diagram of proposed work

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VI. CONCLUSION

This AC architecture can meet many high speed image compression requirements. In Real time fields Satellite images, High Speed Camera Images it gives excellent compression results.

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