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VLSI Implementation of Color Image Compression Based on Boundary Adaptive Quantization and Linear Predictive Modeling

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***Abstract*—The paper deals with scanning an image using Hilbert scanning technique which itself provides relatively a better compression rate when compared to other scanning techniques such as progressive scanning, interlaced scanning , raster scanning which are the most common techniques in the field of image compression. An adaptive quantization scheme based on fast boundary adaptation rule (FBAR) and differential pulse code modulation (DPCM) procedure, least storage quadrant tree decomposition (QTD) processing is adapted in order to perform compression. Image reconstruction is performed to recover the Original image. The Major objective of the paper is to reduce the compression bit-per-pixel (BPP) otherwise known as Entropy, while maintaining reasonable peak signal-to-noise ratio levels for any image and could be implemented on VLSI. The Compression parameters such as PSNR, Mean Square Error, and Entropy are tabulated for different compression algorithms, different image sizes which ensure the objective of the paper.**

***Index Terms*---Raster scan, Hilbert scan, Differential Pulse Code Modulation, Data Compression, Compression Ratio.**

I.INTRODUCTION

Nowadays, transceiving data in minimum bandwidth is an essential in the field of satellite communication, military application, etc. To accomplish it one cannot increase the bandwidth but at the same time it is impossible to omit certain data. The only thing to be done is compressing the data for instance an image. Image compression is minimizing the size (in bytes) of a graphics file without degrading the quality of the image to an unacceptable level. The reduction in file size allows more images to be stored in a given amount of disk or memory space. It also reduces the time required for images to be sent over the Internet or downloaded from Web pages. For example, in a wireless video sensor network, limited by power budget, communication links among wireless sensor nodes are often based on low bandwidth protocols, such as Zig Bee (up to 250 kb/s) and Bluetooth (up to image sensor can barely stream an uncompressed 320 X 240 8-bit video at 2 frame/s. To avoid communication of raw data over wireless channels, energy efficient single chip solutions that integrate both image acquisition and image compression are required. Discrete wavelet transform (DWT), among various block-based transforms, is a popular technique used in JPEG-2000 image/video compression standard. However, implementation of image/video compression standards in cameras is computationally expensive, requiring a dedicated digital image processor in addition to the image sensor 1 Mb/s). Even at the data rate of Bluetooth, conventional In the proposed paper Image Compression and Decompression is performed based on adaptive quantization scheme based on fast boundary adaptation rule (FBAR) and differential pulse code modulation (DPCM) procedure, least storage quadrant tree decomposition (QTD) processing is adapted in order to perform compression. The fresh method is come under both lossy as well as lossless compression Techniques since using predictive modelling.

II.EXISTING METHOD

A.HILBERT SCANNING

The adaptive quantization process explained earlier permits to build a binary image on which QTD can be further employed to achieve higher compression ratio. The QTD compression algorithm is performed by building a multiple hierarchical layers of a tree which corresponds to a multiple hierarchical layers of quadrants in the array. To scan the image data out of the pixels array, many approaches can be employed. The most straightforward way is, for example, raster scan or Morton scan [1]. However the choice of the raster scan sequence is very important as it highly affects the adaptive quantizer and QTD compression performance [2]. Generally speaking, block based scan can result in higher peak signal-to-noise ratio (PSNR) and compression ratio because it provides larger spatial correlation, which is favourable for the adaptive quantization and QTD processing. Fig 2.1 illustrates a typical Morton (Z) scan which is used to build the corresponding tree as reported in. In this approach, transition from one quadrant to the next involves jumping to a non-neighbouring pixel, which results in spatial discontinuity, which gets larger and larger when scanning the array due to the inherent hierarchical partition of the QTD algorithm. This problem can be addressed by taking the boundary point from the physically nearest neighbour of the previous quadrant rather than the previously scanned pixel. Unfortunately, this solution comes at the expense of two additional 8-bit registers for each level of the quadrant. As shown in Fig 2.2 two registers are needed to store the boundary point for the 4*4 quadrant level and two other registers are needed to store those related to the 8*8 quadrant level. Fig 2.2 illustrates an alternative solution using Hilbert scan sequence [3]. In this scheme, multilayers hierarchical quadrants are sequentially read-out while maintaining spatial continuity during transitions from quadrant to the next. The storage requirement issue is also addressed in this scheme as for the adaptive quantization processing, the neighbouring pixel values are the ones just consecutively scanned.

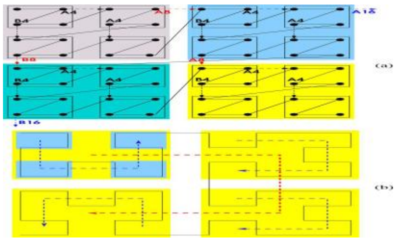

Fig. 2.1 Boundary Point Propagation Scheme Using Morton (Z) Scan
Fig. 2.2 Hilbert Scan Patterns At Each Hierarchy For an 8 * 8 Array.

B. IMAGE COMPRESSION—ALGORITHMIC CONSIDERATIONS

A. Existing Block Diagram

The Existing block diagram Consists predictive modelling block, Differential pulse Code modulation block. Initially image is applied to the Predictive modelling block where predicted image is compressed and the compressed image is going to be modulated by means of DPCM (Differential pulse Code modulation).

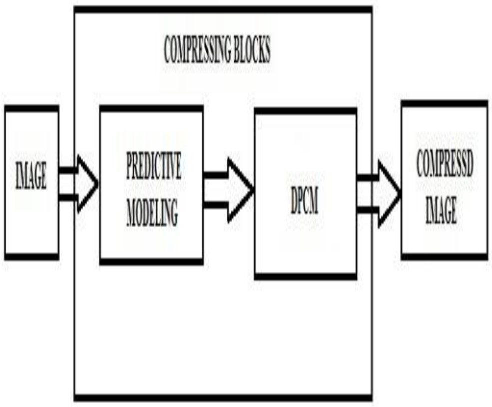

Fig. 2.3 Existing Block Diagram

The exact replica is going to occur in Decompressing the Image. The further part of this section will deal with the predictive modelling and DPCM Technique [4].

B. Predictive Modelling

Predictive Modelling contains two sections which includes Compression part and decompression part. The Compression part deals with predicting, rounding off and mixing the pixel values .Mixing is either addition or subtraction of the image pixel values. The Compression part is explained in fig 2.4.

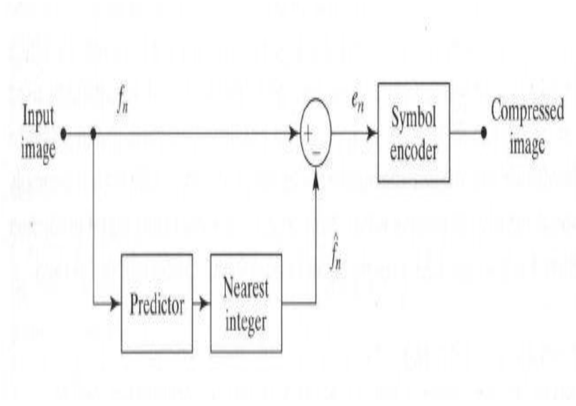

Fig. 2.4 Predictive modelling - Compression

The image is directly given to both mixer, predictor where the predictor predicts the pixel values based on predicting technique and mixer at instance subtracting the pixel values of image which is given directly with the predicted and rounded pixel values.

The error is coded using symbol encoder and modulated using DPCM [6]. The decompression part is illustrated in fig 2.5.

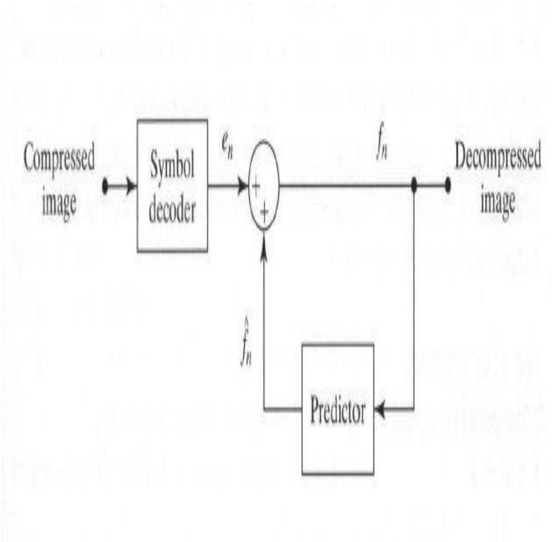

Fig. 2.5 Predictive modelling – Decompression

This is the exact replica of the compression part. The compressed image is decoded with the symbol decoder which is fed as input to the mixer which acts as a combiner here (ie) adding the decoded compressed image pixel values with the predicted feedback signal. All these will fetch the Original or decompressed image.

C. Differential pulse Code Modulation

Differential pulse-code modulation (DPCM) is a signal encoder that uses the baseline of pulse-code modulation (PCM) but adds some functionality based on the prediction of the samples of the signal. The input can be an analog signal or a digital signal.If the input is a continuous-time analog signal, it needs to be sampled first so that a discrete-time signal is the input to the DPCM encoder.

1. Option 1: take the values of two consecutive samples; if they are analog samples, quantize them; calculate the difference between the first one and the next; the output is the difference, and it can be further entropy coded.
2. Option 2: instead of taking a difference relative to a previous input sample, take the difference relative to the output of a local model of the decoder process; in this option, the difference can be quantized, which allows a good way to incorporate a controlled loss in the encoding.

Applying one of these two processes, short-term redundancy (positive correlation of nearby values) of the signal is eliminated; compression ratios on the order of 2 to 4 can be achieved if differences are subsequently entropy coded, because the entropy of the difference signal is much smaller than that of the original discrete signal treated as independent samples. DPCM was invented by C. Chapin Cutler at Bell Labs in 1950; his patent includes both methods.

C. QUANTISATION

Quantization of an image pixel leads to approximating or rounding off the pixel value to a nearest one. In this technique a threshold is fixed, the pixel value is subtracted with or by the threshold value which could further divided by del operator. However the selection of operation depends on the Del operator which could be fixed by trial and error method [5].

III.PROPOSED WORK

The proposed enhancement of this paper is to reduce the compression bit-per-pixel (BPP), while maintaining reasonable peak signal-to-noise ratio levels in a colour image using predictive modelling along with QTD algorithm which could further be implemented in VLSI. Predictive modelling technique is well explained in previous section. Thus we are in need to know what QTD algorithm is. The QTD algorithm can be illustrated as follows. A quadrant tree is a tree data structure in which each internal node has exactly four children. Quadrant trees are most often used to partition a two dimensional space by recursively subdividing it into four quadrants or regions. The regions may be square or rectangular, or may have arbitrary shapes.

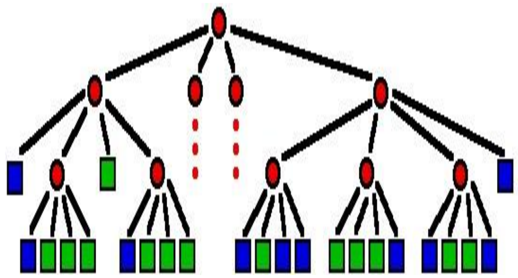

Fig. 3.1 Quad tree

A quad-tree decomposition approach is proposed for cartoon image compression in this work. The proposed algorithm achieves excellent coding performance by using a unique quad-tree decomposition and shape coding method along with a GIF like colour indexing technique to efficiently encode large areas of the same colour, which appear in a cartoon-type image commonly.

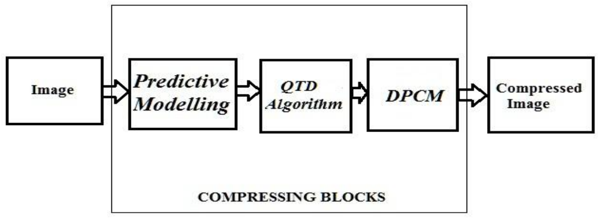

Fig. 3.2 Proposed Block Diagram

To reduce complexity, the input image is partitioned into small blocks and the quad-tree decomposition is independently applied to each block instead of the entire image. The LZW entropy coding method can be performed as a post processing step to further reduce the coded file size. It is demonstrated by experimental results that the proposed method outperforms several well-known lossless image compression techniques for cartoon images that contain256 colours or less.

IV.RESULT AND COMPARISION

The Compressed Image obtained by the proposed algorithm and the reconstructed image is shown.

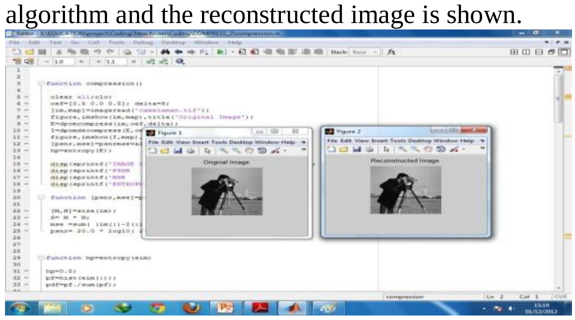

Fig. 4.1 Original, Reconstructed image

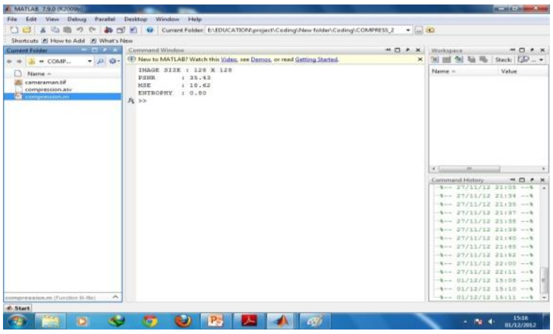

Fig. 4.2 Associated Parameters

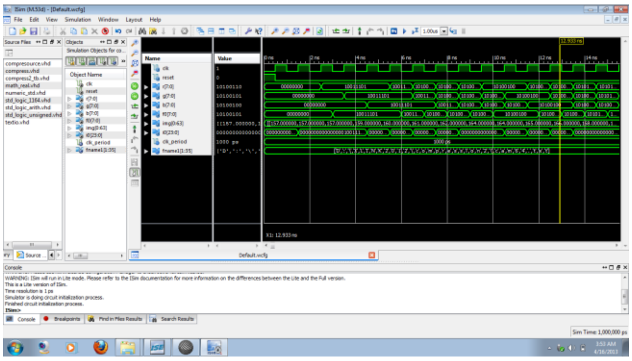

Fig 4.3 VLSI Implementation of Image Compression

TABLE I
VARIOUS ALGORITHMIC COMPARISONS OVER A GRAY SCALE IMAGE.

MODES	SIZE OF IMAGES					
	64 X 64			128 X 128		
	PSNR	BPP	MS E	PSNR	BPP	MS E
ƞSMOOT H MZ	22.37	0.96	23.3	23.83	0.90	26.3
ƞ-HILBER T	22.77	0.98	23.1	24.26	0.93	26.1
ƞ-HILBER T + DPCM	23.06	0.88	24.6	24.62	0.88	30.2
DCT	19.28	0.91	21.1	30.16	0.82	37.7
PREDIC TIVE BOUND ARY ADAPT ATION	35.42	1.31	18.6	35.43	0.80	18.6

TABLE II
IMAGE PARAMETER VALUES FOR DIFFERENT TEST COLOUR IMAGES

TEST IMAGES (512 x 512)	PSNR	BPP (Bits per Pixel)	Mean Square Error
Lena	35.41	1.02	18.71
Cameraman	35.43	0.80	18.62
baboon	35.40	1.25	18.75
airplane	35.58	1.05	18.01

V.CONCLUSION

The Existing compression algorithm enables about 25% improvement in terms of performance (PSNR to BPP ratio) compared to the first generation design. Reported performances are clearly superior to that of a standalone QTD and quite comparable to DCT-based compression. This is due to the inherent advantage of boundary adaptation processing requiring simple addition, subtraction, and comparison for ƞ adaptation. The storage requirement is however quite demanding for QTD processing since a tree construction and storage is required, however, this issue is addressed in this paper by introducing a QTD algorithm with pixel storage reuse technique. The memory is therefore embedded within the pixel array but also interacts with the compression processor for further processing storage. The achievement of this paper is, reducement of the compression bit-per-pixel (BPP), while maintaining reasonable peak signal-to-noise ratio level for an image using Predictive modelling Technique, added with QTD algorithm which further improves the compression.

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