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A Survey on Error Free Image Compression for Various Coding and Transform Techniques

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Abstract

Digital Image processing will takes place an important vital role in various applications, to transmit the larger size of the image, huge bandwidth is required; instead of using the huge amount of bandwidth, the image must be compressed, and then should send via transmission medium with less bandwidth, that will be very fast due to reduction of bits and bytes of the image data with or without losing the some parts of information. When we do compression, we must look in to the some important parameters, they are compression ratio (CR), peak to signal Noise Ratio (PSNR), mean square error (MSE) and bits per pixel (bpp), the image compression has numerous applications they are, natural images, medical images, satellite images, forensic images, remote sensing and those images are applying in to the various coding techniques, then we have to achieve the better performance. This paper outlines the comparison between the various methods applied in error free compression such as predictive coding method, transform coding method, wavelet method.

***Keywords**: lossless compression; predictive coding, transform coding, DWT, medical images, filter bank, decomposition.*

1. Introduction

Image compression is to reduce the irrelevant and redundancy of the image data, it should be able to store and transmit the data very efficiently. The principal basis of the reduction process is the removal of redundant data, from a mathematical view point, these amounts to transforming a two dimensional pixel array in to a statistically uncorrelated data set. The transformation is applied prior to storage or transmission of the image. After some time, the compressed image is decompressed to reconstruct the original image or approximately Image compression is to minimize the size in bits and bytes of a picture without losing the quality of an image. Image compression classifies in to two types they are (i) lossy compression (ii) error free compression [1].

Table 1 Multimedia data Types

Multimedia Data	Size/duration	Bits/pixel or bits/sample	Uncompressed Size (in Bytes)	Transmission Bandwidth (in bits)	Transmission time (using a 28.8K modem)
A Page of text	11" X 8.5''	Varying resolution	4-8 KB	32-64 Kb/page	1.1-2.2 sec
Grey scale Image	512 X 512	8 bpp	262 KB	2.1Mb/image	1 min 13 sec
Color Image	512 X 512	24 bpp	786 KB	6.29Mb/image	3 min 39 sec
Medical Image	2048 X 1680	12 bpp	5.16 MB	41.3 Mb/image	23 min 54 sec
SHD Image	2048 X 2048	24 bpp	12.58 MB	100Mb/image	58 min 15 sec

Lossy image compression is nothing but the information will be lose after compression, and can achieve more compression ratio; it is useful in applications like broadcasting, video conferencing and facsimile transmission. Error free (or) Lossless image compressing is nothing but the information will be preserve, it allows an image to be compressed and decompressed without losing the information i.e, reconstruct perfectly.

The following parameters should be considered for to do compression, they are compression ratio, PSNR, MSE, bpp.

$$Compression\ Ratio(CR) = \frac{Image\ before\ compression}{Image\ after\ compression} \ldots\ldots\ldots\ldots..(1)$$

Normally compression ratio will be 10:1 means that the data set has 10 information carrying units for every one bit in the second or compressed data set [2]. High compression ratio yields the not good quality of the image.

$$PSNR = 10\ log_{10}\frac{255^2}{MSE^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where MSE is root mean square error.

$$MSE = \left\{\frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}[\ \hat{g}(x,y) - f(x,y)]^2\right\}^{1/2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(3)$$

Where

f(x, y) represents an input image and $\hat{g}(x,y)$ represents estimates or approximation of f(x, y)

from the above parameters to be considered for to compress the image, there is a trade-off between the compression ratio and

PSNR [40] yields low quality image, more PSNR and MSE will produce the low quality image.The bits per pixel (bpp) can be calculated from the entropy, the entropy defined as the measure of average information per symbol.

$$H = -\sum_{k=0}^{l-1} p_r(r_k) log_2 p_r(r_k) \ \frac{bits}{pixel} \ldots\ldots\ldots\ldots\ldots (4)$$

A Lossy Compression

Lossy compression will lose the information; there will more difference between the input images to the output image, it will affect the quality of the image. The application of lossy is natural images, the lossy image compression has different approaches, and they are [3]

- Predictive coding – Delta modulation (DM), Differential pulse code modulation (DPCM)
- Transform coding – DFT, DCT, KLT, WHT
- Wavelet coding – DWT

In predictive coding, the information already sent or available is used to predict future values, and the difference is coded, since this is done in directly on pixels in image [4]. Predictive coding is based on quantizing each individual differential pixel followed by entropy coding. Because predictive coding is based on coding each pixel at a time, it is not possible to achieve fractional bit rates. It is relatively simple to implement and is readily adapted to local image characteristics. Differential pulse code modulation (DPCM)[1] is one particular example for predictive coding. The advantage of this method is to reduce the spatial and coding redundancy.

Transform coding, on the other side, it is based on quantizing a block of transform coefficients followed by entropy coding of the quantized coefficients. The idea behind applying a unitary transform to a block of pixels is to decorrelated the pixels and compact the energy in the pixels into as few coefficients as possible with the result that only a few significant coefficients need to be coded, hence the compression. Unlike predictive coding, a different number of bits of quantization in an optimal fashion can be used for the transform coefficients to realize as low a bit rate as possible.

Therefore, it is feasible to achieve fractional bit rates on an average in the transform domain.

In transform coding, a block of image pixels or sub images pixels is linearly transformed into another block of transform coefficients of the same size as the pixel block with the hope that only a few of the transform coefficients will be significant and the rest may be discarded. This implies that storage space is required to store only the significant transform coefficients, which are a fraction of the total number of coefficients and hence the compression. The original image can be reconstructed by performing the inverse transform of the reduced coefficient block. It must be pointed out that the inverse transform must exist for unique reconstruction. There are a number of such transforms available in the field to choose from, each having its own merits and demerits. The most efficient transform is one that uses the least number of transform coefficients to reconstruct the image for a given amount of distortion. Such a linear transform is known as the optimal transform where optimality is with respect to the minimum mean square error between the original and reconstructed images. This optimal image transform is known by the names Karhunen–Lo`eve transform

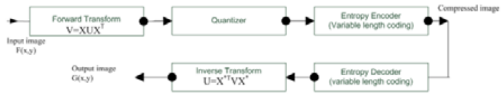

Fig. 1 Block diagram of transform coding

(KLT) or Hoteling transform. The disadvantage of the KLT is that the transform kernel depends on the actual image to be compressed, which requires a lot more side information for the receiver to reconstruct the original image from the compressed image than other fixed transforms. A highly popular fixed transform is the familiar discrete cosine transform (DCT). The DCT has very nearly the same compression efficiency as the KLT with the advantage that its kernel is fixed and so no side information is required by the receiver for the reconstruction. The DCT is used in the JPEG and MPEG video compression standards. The DCT is usually applied on no overlapping blocks of an image. Typical DCT blocks are of size 8 × 8 or 16 × 16. One of the disadvantages of image compression using the DCT is the blocking artifact. Because the DCT blocks are small compared with the image and because the average values of the blocks may be different, blocking artifacts appear when the zero-frequency (dc) DCT coefficients are quantized rather heavily. However, at Low compression, blocking artifacts are almost unnoticeable.

Wavelet (ψ) is a small wave of varying frequency and limited duration. Wavelet transform captures both long-term and short-term changes in an image and offers a highly efficient compression mechanism. As a result, it is used in the latest versions of the JPEG standards as a compression tool. Even though the wavelet transform may be applied on blocks of an image like the DCT, it is generally applied on the full image and the various wavelet coefficients are quantized according to their types. 2D DWT decomposes an image into one approximation and many detail coefficients. The number of coefficient sub images corresponding to an L-level 2D DWT equals $3 \times L + 1$. Therefore, for a two-level 2D DWT, there are seven coefficient sub images. In the first level, there are three detail coefficient sub images, each of size 1/4 the original image. The second level consists of four sets of DWT coefficients—one approximation and three details, each 1/16 the original image. As the name implies the approximation coefficients are lower spatial resolution approximations to the original image. The detail coefficients capture the discontinuities or edges in the image with orientations in the horizontal, vertical, and diagonal directions. In order to compress, an image using 2D DWT we have to compute the 2D DWT of the image up to a given level and then quantize each coefficient sub image. The achievable quality and compression ratio depend on the chosen wavelets and quantization method. The visual Effect of quantization distortion in DWT compression scheme is different from that in DCT-based scheme.

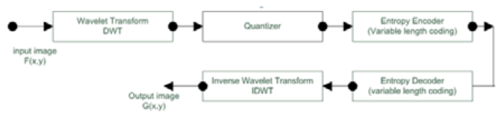

Fig. 2 Block diagram of image compression using wavelet transform

B Lossless compression

The lossless image compression will preserve the information after reconstruction of the image perfectly; there will not be difference with the input image to the out image. It is completely reversible process and is used where loss of information cannot be accept such as medical imaging, satellite imaging, forensic, GIS[3], legal and bank documents etc.., This will provide very low compression ration generally in between 2:1 and 10:1. The lossless image compression classifies in to several types, they are

- Variable length coding
- Adaptive Dictionary based coding
- Run length coding
- Chain codes
- Predictive coding
- Transform coding
- Wavelet coding

Variable length coding reduces the coding redundancy present in the entropy grey level of an image, there are two approach shortest codes are there in variable length coding, they are Huffman coding and arithmetic coding. Huffman coding will remove the coding redundancy and produces possible number of code symbols per symbol. The advantage of this code is to provide minimum redundancy code and optimal for a given data and it is computationally very simple and generates minimum redundancy codes. The disadvantage of this code is that decoder must have the knowledge of the probabilities of symbols in the compressed file.Arithmatic coding is used for the source with small alphabets such as binary source and alphabets with very different probabilities. This code is a statistical coding that separates the real number interval between 0 and 1 into segments according to symbol probabilities. The advantage of this code is equivalently to the Huffman coding, the arithmetical coding tries to evaluate the probability with which certain symbols appear and to optimize the length of the required and the efficiency is good. Then disadvantage of this code is for high requirements for calculation and it will take more time, it is slower than Huffman coding.

Dictionary based coding is very popular coding that will use Lempel ziv weltch (LZW), it is used to construct the dictionary for repeated word used.LZW is an adaptive dictionary based , encoding scheme that uses fixed length code words to represent variable length strings. LZW encoder and decoder generate the same dictionary dynamically while receiving the data. LZW also performs well when presented with extremely redundant data files. The advantage of this code will reduce the one complete English text file word in to half size of the original. This will be best suited for GIF, TIFF and PDF.

Run length coding is a simple compression method is used for sequential data.it very useful to identify the repetition of the data. This will replace the identical pixels, its works on reducing the size of the repeating string of characters. Encoding done in two bytes, first byte represents the number of characters of the run and is called run count. The second byte is the value of the character in the run and is called run value. This compression algorithm exclusively used in bit map file formats such as TIFF, bmp.the advantage of this coding is very effective while compressing the binary data or images, especially for black and white images.

Chain code will be used for monochrome image; this code is to encode the connected component separately in the image, for that type of region a boundary point is selected and those coordinates are transmitted. Again the encoder moves a point to boundary of the region at each step and ti will be transmit a symbol representing the direction of this direction. This will continues until encoder reaches the starting point. The encoding method is classified in to different types they are Freeman Chain Code of Eight Directions, Vertex Chain Cod, Three Orthogonal symbol chain code and Directional Freeman Chain Code of Eight Directions.

2. Predictive coding based existing algorithms and its problems

Predictive coding [4] method exploits interpixel redundancy present in an image for image compression. As there is a lot of correlation in the pixel values of an image, these values scan be predicted from its neighbour's values. Sequence of similar valued pixel can be found along the rows and columns if an image. The idea in predictive coding is that rather than transmitting actual grey level values of an image, we rather transmit the prediction error which is very small as compared to the pixel value itself. The reason for small prediction error is high degree of correlation among the pixel values. More complicated predictors may give better results but need more computational power and memory to store previous pixels. S.Arya *et al* [1] proposed the an optimal algorithm for approximate nearest neighbour's searching fixed dimension, this algorithm provides significant improvements over brute-force search in dimensions as high as 20, with a relatively small average error, this algorithm based on hierarchical decomposition of space in to d0dimensional rectangles whose sides are orthogonal to the coordinate axes called as balanced box decomposition (BBD) tree, and this method provides practical efficiency, this algorithm has some problems, the number of data midpoint are tightly clustered and resulting shrinking box does not necessarily contain the inner box of the original cell.

N.Memon *et al* proposed [2] predictive technique for EEG signals, the algorithm was used for context based image compression by bias cancellation method and activity based condition coding compares with various existing algorithms, and he proposed the AR based predictive coding technique to achieve perfect reconstruction. The simple first-order predictor cannot remove all the structures within the original EEG sequence, and effective EEG compression can be done by a simple first-order predictor followed by bias cancellation and conditional coding. Y.-H. Huang et al [82] proposed the non-block and texture based approach algorithm of error diffused images , and he proposed multi template based algorithm, which will give the better compression ratio compare to earlier methods. Z. Chen *et al* [18] has proposed the novel method an adaptive predictive multiplicative autoregressive (APMAR) method is proposed for lossless medical image coding. The adaptive predictor is used for improving the prediction accuracy of encoded image blocks in our proposed method. Each block is first adaptively predicted by one of the seven predictors of the JPEG lossless mode and a local mean predictor. It is clear that the prediction accuracy of an adaptive predictor is better than that of a fixed predictor. Then the residual values are processed by the MAR model with Huffman coding. Comparisons with other methods [MAR, SMAR, adaptive JPEG (AJPEG)] on a series of test images show that our method is suitable for reversible medical image compression. J. a Robinson et al.[73] proposed the complete general purpose method for still image compression called adaptive prediction trees, efficient lossy to lossless compression of images was achieved by ordering the data in multicomponent n binary pyramid, it will provide better average compression than the standard lossless alternatives

R.Pajarola *et al* [3] proposed the algorithm for spatial search directly on to the compressed image, he proposed the Hilbert curve [22] and special compression algorithm on raster image, here focus on the interplay between compression and spatial access, this algorithm runs fast even without code optimization, the compared the spatial selectivity of the Hilbert curve and the scan-line approach when used for data clustering with fixed sized space filling curve (SFC) data blocks. This algorithm tested for

LANDSAT satellite mage and this algorithm won't do more compression for higher resolution. . O. Egger *et al* [19] proposed the nonlinear prediction model for subband decomposition. A polynomial model selection was presented its capable of capturing spatial information as well as rank order information of an image. The combination of the sub band decomposition and non-prediction method called ROPD, the ROPD is a product of further development of the morphological sub band decomposition (MSD) that itself an efficient compression method, in this the functionality of having a completely embedded bit stream, this means that image is compressed losslessly can decompressed at any bit rate. From this method it is observed the quality is increasing with an increasing bit rate and also the PSNR has tend to infinity at the lossless bit rate.in this context, the coding technique was applied in to the region of interest (ROI), and this method compared with the very popular methods like SPIHT, WTCQ and JPEG with only 5% of the lossless bit stream is necessary to have an image of good browsing quality. J. Jiang [20] proposed the novel algorithm for a low cost content adaptive and rate controllable near lossless image codec in DPDC domain that will optimize the PSNR and optimize the perceptual quality of reconstructed images.

O. E. Kia *et al* [14] proposed the concept to preserve the overall document and reduce the redundancy of data with the help of content based binary arithmetic coder and various structure coding for document image compression. N. Memon *et al* [22] proposed the new predictive coding algorithm which developed an approach for quantitatively analyzing the effect of pixel scan order for context-based, predictive lossless image compression and used to compare raster, Hilbert, random and hierarchical scans. Assume an isotropic image model and contexts consisted of previously scanned adjacent pixels, it is found that the raster scan is better than the Hilbert scan which is often used in compression applications due to its locality preserving properties. Since they had used a bigger context neighborhood in their progressive scan, it is not entirely fair to compare it with the raster and Hilbert scans [3] the latter scans would achieve further increase in gain with an enlarged context neighborhood. However, it is significant that in fact, very little is gained by using the progressive scan even with its larger neighborhood.

M. J. Weinberger *et al* [28] proposed the novel Low complexity lossless compression for images (LOCO-I) for new ISO/ITU standard for lossless compression for continuous tone images. Here they used the Golomb code, which are adaptively chosen, and an embedded alphabet extension for coding of low-entropy image re gions. LOCO-I attains compression ratios similar or superior to those obtained with state-of-the-art schemes based on arithmetic coding. It's compared to [14] this will provide the compression ratio of 3.06 bps compare with the well know algorithms like LOCO-A, FELICS, JPEG-LS and Huffman coding, at the same time this will give reduce the decompression speed by 10% slower than the compression. X. Wu *et al* [29] proposed the L-infinity constrained high hi-fi image compression via adaptive context modeling, its compared with the [28][14] this will provide the increasing the PSNR by 1 DB or reduce the bit rate by 10%, here they got the bit rates is 1.25bpp, even though it has compared with the SPIHT for various values of δ. X. Wu *et al* [30] presented the interband version of CALIC (context-based, adaptive, lossless image codec), it will provide effective compression of multispectral images. The proposed interband CALIC exploits interband and intraband statistical redundancies and obtain significant compression gains over the interband counterpart, interband CALIC will provide the reduction of bit rate more than 20% compared to [28], it will provide the compression ratio of 2.72 bpp.

N. V Boulgouris *et al* [35] approached two methods of sampling to achieve optimal prediction adaptive arithmetic filter, they are quincunx and simple row and column, both will give the efficiency of linear predictors. First method uses the direct post processing, and the second method uses the adaptive post processing both the method was performed well, with leading to lower first order entropies than other methods, with AL being more efficient than MINT-U in most cases. M. T. Orchard et al[38] proposed the least-square (LS)-based adaptive prediction schemes for lossless compression of natural images, it shows that the superiority of the LS- based adaptation s due to its edge directed property. This enables the predictor to adapt reasonably well from smooth regions to edge areas. Recognizing that LS-based adaptation improves the prediction mainly around the edge areas, they presented a novel approach to reduce its computational complexity with negligible performance sacrifice than the CALIC. The LS optimization is performed only for a fraction of pixels in the image. The performance and the complexity of this lossless image coder built upon the edge-directed prediction lie somewhere between those of CALIC and TMW. M. D. Reavy et al [39] proposed the block arithmetic coding for image compression (BACIC), which can be replaced by JBIG, it is simple, efficient, easy to implement and variable to fixed arithmetic coder to encode the images BACIC models its probability estimates adaptively based on a 12-bit context of previous pixel values; the 12-bit context serves as an index into a probability table whose entries are used to compute I (the probability of a bit equaling one), the probability measure BAC needs to compute a codeword BACIC's overall compression ratio is 19.0 for the eight CCITT test images (compared to JBIG's 19.6 and G3's 7.7), is 16.0 for 20 additional business-type documents (compared to JBIG's 16.0 and G3's 6.74), and is 3.07 for halftone images (compared to JBIG's 2.75 and G3's 0.50).

E. S. Hong et al [42] presents novel based embedded wavelet based image compression algorithm based on a concept of group testing for wavelet (GTW), here they used Golomb coding instead of SPIHT-arithmetic coding, which performs competitively with SPIHT-AC variant in terms of rate distortion performance. Here they compared the rate-distortion performance of GTW with that of SPIHT (without arithmetic coding) and SPIHT-AC (with arithmetic coding).GTW was significantly better than SPIHT and close to SPIHT-AC over a large range of bit-rates. R. Zhang et al [77] proposed the image entropy coder, con- text-based bit-plane Golomb coder (CB-BPGC), for wavelet-based scalable image coding. CB-BPGC follows the idea of the standard JPEG2000 entropy coding to apply the rate-distortion optimization algorithm after block coding, which achieves the better lossless and lossy coding performance with lower complexity than [28,42]. S. Kasaei et al [43] proposed the new algorithm using wavelet packets and lattice vector quantization which will determine the largest radius of the lattice used and its scaling factor, for both uniform and piecewise-uniform pyramidal lattices, which will give the best rate distortion function, then compared to others algorithms which will provide high quality reconstructed images for identical bit rates. G. Rath et al [85] proposed the laplacian pyramid to reduce the aliasing in the lower resolution, and it will give the better compression efficiency of the open loop laplacian pyramid through interlayer prediction and orthogonal spatial transform.

K. Ratakonda et.al [46] developed the optimal amount of segmentation information to exploit spatial redundancies inherent in image data, they proposed algorithm, that trimes the tree to control the size and number of regions thus obtaining a rate optimal balance between the overhead inherent in coding the segmented data and the coding gain that we derive from it. Another novelty of the proposed approach was, they used an image model comprised separate descriptions of pixels lying near the edges of a region and those lying in the interior. Results shows that the proposed algorithm will be provide performance comparable to the best available methods and 15–20% better compression when compared with the JPEG lossless compression standard for a wide range of images.

C. S. Lee et al [50] developed the new technique for bilevel image compression method for error diffused images with two passes using Bayes theorem The sum value (S -value) of a cell is encoded in the first pass, and the cell value (C -value) is encoded in the second pass. The proposed method was designed on the basis of Bayes' theorem. Only decoding the bit streams compressed in the first pass, and then it can reconstruct nearly lossless bilevel images with the proposed method. When it compresses the error-diffused bilevel images without information loss using two passes of the proposed method, it is comparable to the JBIG's [39]. In addition, with the proposed method it is possible to encode or decode bilevel images progressively. While the progressive coding of the JBIG contains resolution scalability, the proposed method contains SNR scalability. The quality of images reconstructed from the first pass of the proposed method is better than one reconstructed from layer 1 of the progressive coding of the JBIG. S. Xiao et al [76] proposed the context-weighting algorithm that adaptively weights in real-time three-context models based on their relative accuracy. that can automatically select the better model over different regions of an image, it has produced better probability estimates than using either one of these models exclusively.

S. Forchhammer et al [53] proposed the optimal context quantization technique, this also be used to establish a lower bound on the achievable code length, and hence it is a useful tool to evaluate the performance of existing heuristic context quantizers The techniques were developed for optimizing contexts in which a binary random variable may be coded by adaptive arithmetic coding. Non-binary data can also be coded by these techniques if they are decomposed into a binary representation. Fast CQ design algorithms based on dynamic programming were developed and analyzed, especially with respect to the adaptive code length (the case of MCLCQ). In a specific application, the new CQ design algorithms were used to evaluate the performance of existing heuristic context quantizers used to compress digital maps. Also, in conjunction with a binary decomposition based on the (estimated) likelihood of the possible values of the input random variable, a coding scheme was developed for image (sequence) data. This approach may be used for tiles of an image as well, for example, in browsing of digital maps.

V. Dai et al [68] presented the novel lossless compression algorithm called Context Copy Combinatorial Code (C4), which integrates the advantages of two very disparate compression techniques: context-based modeling and Lempel–Ziv (LZ) style copying, and it will give the efficient as arithmetic coding, and as fast as Huffman coding compared to [2] achieves lossless compression ratios greater than 22 for binary layout image data, and greater than 14 for gray-pixel image data. W. Lin et al [69] achieved better coding quality by downsampling the image prior to compression and estimating the missing portion after decompression, proposed algorithm significantly raises the critical bit rate to approximately 1.2 bpp, from 0.15–0.41 bpp in the existing down sample-prior-to-JPEG schemes and, therefore, outperforms the standard JPEG method in a much wider bit-rate scope. J. Malo et al [70] proposed the adaptive nonlinear image representation in which each coefficient of a linear transform is divided by a weighted sum of coefficient amplitudes in a generalized neighborhood then showed that the divisive operation greatly reduces both the statistical and the perceptual redundancy amongst representation elements which will give better PSNR. J. H. Park et al [71] proposed an efficient representation method of the disparity map for view interpolation and stereo image compression Image regions that had a high horizontal gradient were more important than the other, lower gradient regions for the quality of the view-interpolated image, the proposed method produced better quality view-interpolated images and had better performance in stereo-image compression than [70]. S. X. Chen et al [83] proposed the fast algorithm for vector quantization encoding basis of vectors and subvectors, it will reject the more codewords, while holding the same quality of encoded images as full search algorithm, which will reduce the distortion calculation by 8% to 61%. Ø. Ryan et al [87] proposed the images can be processed directly on to the runlength represented form and it can be improve the processing time and compression ratio for low it depth images like GIF, TIFF compared ti JPEG2000.

2.1 Transform coding based existing algorithms and its problems

S. Phoong *et al* [26] proposed the new approach transform called as prediction based lower triangular transform (PLT), compared to KLT, that transform implementation is low cost, the design cost will be lower than the order of $O(M^2)$, that will provide the minimum noise structure that have roughly the same complexity as the direct implementation of PLT., its noise gain unity even though the transform is not unitary, then perfect reconstruction was guaranteed, then it required (M-1) multiplications and addditons.the advantage of this coding transform is better than the DCT, which will provide the ρ range between 0.85 and 0.95. P. Hao *et al* [36] proposed the matrix factorization for reversible integer mapping by two forms, Concepts of the integer factor and the elementary reversible matrix (ERM) for integer mapping are introduced, and two forms of ERM, triangular ERM (TERM) and single-row ERM (SERM), The advantages of the integer implementations of an invertible linear transform are mapping integers to integers, perfect reconstruction, and in-place calculation. There are at most three TERMs or at most N+1 SERMs for an N x N nonsingular matrix, except for a possible per- mutation matrix in the TERM or the SERM factorization. The numbers of ERMs are generally optimal.

J. L. Paredes et al [45] presented the new approach to multichannel image compression was introduced algorithm for bijection mapping of the multichannel image into a virtual 2D scalar image. The bijection mapping can be optimized to minimize the distortion introduced by the compression algorithm. The optimization reduces to the maximization of a function of the second-order statistics of the multichannel data. At high compression rates, the new algorithm outperforms traditional compression algorithms whenever the cross-band correlation is high and it yields comparable performance at low compression rates. C. Tu et al [47] presented a simple, fast, and efficient adaptive block transform image coding algorithm based on a combination of prefiltering, postfiltering, and high-order space–frequency context modeling of block transform coefficients. Despite the simplicity constraints, that results proposed coder achieves competitive rate distortion (R-D) performance compared to the best wavelet coders in the literature.

H. Park et al [52] proposed a novel approach to resize images in the transform domain. This approach is based on the multiplication convolution property of DCT. Here it shows that the multiplications of the window functions in the spatial domain turn into the symmetric convolutions in the DCT domain. According to his approach, the filter for image resizing with an arbitrary ratio can easily be obtained in the transform domain. Also, the modified filter matrices were developed for reducing the computational complexity. The proposed approach is computationally faster and produces visually finer images than bilinear interpolation in the spatial domain. Y.S.Park et al [72] proposed the arbitrary-ratio image resizing method for transcoding of the compressed images in DCT domain, which produces visually fine images with high PSNR the resizing ratio, truncating the high-frequency coefficients and padding zeros are appropriately considered by combining the inverse DCT and forward DCT It shows a good peak signal-to-noise ratio and less computational complexity compared with the spatial-domain and previous DCT-domain image resizing methods [52].

M. Primbs et.al [58] proposed the integer to integer transform for 2x2 rotation matrices give estimates of the truncation errors for arbitrary approximating dyadic rationals based on fast DCT, which will give the fast implementation, they replaced the fixed point number by dyadic rationals.

2.2 Chain coding Techniques and its problem

A. J. Pinho *et al* [23] proposed the new encoding technique that uses a simple representation for the transition points. i.e., the map of transition point, the problem of encoding arbitrary contour map can be easily converted in to a problem of lossless image coding. Here they compared that coding technique with the differential chain coding (DCC) that will give better compression ration compare to DCC. These results are compared with JBIG and ad-hoc encoding; with the conclusion JBIG is better. The advantage of this coding technique is the proposed method behaves better than differential chain-coding when the number of active contour elements is relatively large.

2.3 Wavelet coding based existing algorithm and its problems

A Munteanu et *al* [17] proposed the wavelet based compression scheme for medical data base especially for angiogram and telediagonis, the quantization module implements a new way of coding of the wavelet coefficients that is more effective than the classical zerotree coding. The experimental results obtained on a set of 20 angiograms show that the algorithm outperforms the embedded zero tree coder, combined with the integer wavelet transform [5], by 0.38 bpp, the set partitioning coder by 0.21 bpp, and the lossless JPEG coder by 0.71 bpp. The advantage of this method is to achieve the fro economical image transmission over limited bandwidth channel and less complexity of algorithm. The problem in this method, the encoding and decoding speed is different, so these algorithms are not optimized for speed. M.D.Adams *et al* [5] compared and analyzed the various transform with the reversible integer to integer wavelet transforms and in this method PSNR is measured with other transforms, he analyzed various parameters, the difference between the best and worst transform is less than 2%, for the images this differences is more significant. The average bit rate for each transform will be overall 8bpp, for this images of this type, the 5/11-C,5/11-A and 13/7-Ttransforms generally best. And the transform 5/3 and 2/6 will considered very low computational complexity compared to 9/7-F, in this study he found the factors affecting the compression performance for a reversible integer to integer wavelet transform the dynamic range of the coefficients produced by the transform. Therefore, Tradeoffs are involved, and the most appropriate choice of transform depends on the needs of the application at hand. When transforms associated with FIR filter banks are employed, the performance penalty is almost negligible. At low bit rates, the difference in PSNR performance is also small.

H. Kim *et al* [14] proposed the new algorithm using the reversible embedded wavelet transform is one which implements the exact reconstruction of the image in integer arithmetic over a given field. as the extension of the existing reversible embedded wavelet transform , S-transform and TS- transform , they developed the new reversible wavelet transform based on the chosen spline biorthogonal wavelets.by using this method they achieved 10% improvement. A.bilgin *et al* [6] proposed the efficient decoding technique for a single bit stream , the scalable image coding using reversible integer wavelet transform used in this coding technique because normally the wavelet transform will produce floating point coefficients which are not suited for lossless coding applications, and also here he presented the fully scalable image coder consisting of a reversible integer wavelet transform and bit plane coder.in this algorithm he achieved the PSNR 40.49 DB compared to ECECOW[7]. Here the use of parent coefficients in the context formation process to achieve lower complexity, more flexibility in bit stream formation/scalability, and potential parallelism. Integer transforms are less complex and offer excellent progressive decoding performance for the many applications that demand the capability to lossless recover the original image

N. V Boulgouris *et al* [8] has proposed the new method for the formulation of the decomposition on images by reduced pyramids, here they used optimal reduced extended pyramid with variable decimation ratios, which has efficient linear interpolators by implicitly assuming complete homogeneity of the image. Finally they proposed the MORE algorithms; it has higher order arithmetic coder to encode the MORE [9] and S+P transformed images. This algorithm will not provide the better bits per pixels for some images. M. G. S. Dimitrios *et al* [16] proposed the novel methodology of optimal construction for multichannel reduced pyramids by selecting a proper interpolation synthesis post filter as too reduce the variance in each level of the stage. D. Tzovaras *et al* [10] presented the methodology for optimal construction of pyramids to select the interpolation of post synthesis filter to reduce the variance error at each stage of the pyramid, also it provides more efficient for lossless compression. Compared to [10] K. Chung *et al* [12] proposed the optimal construction of reduced pyramids for multichannel signal by selecting the interpolation synthesis filter to minimize the error variance at each stage, it also added the advantage of producing the lossy same as lossless which at lower resolution retain the signal as much as possible. C. Chrysafis *et al* [11] address the problem to reduce the memory in wavelet image compression without losing the significance loss in performance, to overcome the problem they proposed the line based algorithm to implement wavelet transform, in that images are read line by line and only required lines are kept in the low memory and it will provide making the wavelet code this will achieve speed and memory needs, they suggested to use the lattice factorization of the wavelet kernel or by using lift steps to increase the speed .

W. He *et al* [13] proposed the non-separable wavelet , it has experimented with the decomposition and reconstruction, it is compared with the tensor product Haar, daubechhies wavelets D4 and D6, and the very popular biorthogonal wavelets with lengths 9 and 7 which are the wavelets for FBI finger print compression standard. The image compression scheme consist of multilevel wavelet composition, embedded zero tree encoding and decoding, multiwavelets reconstruction, PSNR analysis, the advantage of this non separable wavelet will do better job for the text compression ratio 10:1 and 15:1. G. Lin *et al* [21] proposed the new image coding scheme based on multiwavelets filter banks. First, two-dimensional (2-D) multiwavelets decomposition is performed to original image. Then, several hierarchical trees are constructed in transform domain, and an extension of Set Partitioning in Hierarchical Trees algorithm is proposed to quantize multiwavelet coefficients. MWT image compression method can be improved by coding efficiency because of the inherent good property of energy compaction of multiwavelets filter banks. F. G. Meyer *et al* [24] proposed the fast numerical implementation of the best wavelet algorithm, they are computationally very efficient, then they developed the new fast 2D conventional decimation algorithm with factorized nonseparable by a factor of 4 and faster than four times compared to standard convolution decimation, and the image need not to be transposed., FWP was compared with the SPIHT, the advantage of this algorithm will provide the better PSNR.The problem with that approach was ,when coding images that contain a mixture of smooth and texture feature, the best basis algorithm is always trying to find a compromise between those. Which yield, visually pleasant images, and front that they noticed that ringing artifacts on the border of smooth regions. Y. Cho et al [80] proposed the new method of nonredundant geometrical image transforms that are based on wavelets and directional filter banks. Which will convert the wavelet basis function to a flexible and rich set of directional basis elements by directional filter bank, where they formed a nonredundant transform family, which exhibits both directional and nondirectional basis functions.

D. Taubman et al [25] proposed the new image compression algorithm based on independent Embedded Block Coding with Optimized Truncation of the embedded bit stream(EBCOT), it exhibits state of the art compression performances while producing a bit-stream with a rich set of features, including resolution and SNR scalability together with a "random access" property. This algorithm has modest complexity and is suitable for applications involving remote browsing of large compressed images. This algorithm lends itself to explicit optimization with respect to MSE as well as more realistic psychovisual metrics, capable of modeling the spatially varying visual masking phenomenon. This algorithm performance resolution scalability, SNR scalability and a "random access" capability. All features can coexist-exist within a single bit-stream without substantial sacrifices in compression efficiency. S. D. Servetto *et al* [26] proposed the technique wavelet image coding for multiple description, which is based on a combination of multiple description scalar quantizers with techniques successfully applied to the construction of some of the most efficient subband coders. A given image is encoded into multiple independent packets of roughly equal length, when packets are lost, the quality of the approximation computed at the receiver depends only on the number of packets received, but does not depend on exactly which packets are actually received, and that will provide the maximum of 50% to 60% of PSNR.

K. Attakitmongcol *et al* [30] proposes the Balanced multiwavelet prefilters by two methods to obtain optimal second-order approximation preserving prefilters for a given orthogonal multiwavelet basis, and to minimizing the energy compaction ratio (ECR) of the wavelet coefficients for an experimentally determined average input spectrum, they use the optimal filters are DGHM and CL multiwavelet with order of 3 and p=2, with the balanced multiwavet compare with the other wavelets, they achieved the PSNR for lena image is 25.91DB. W. Berghom *et al* [31] proposed the embedded progressive image coding, here they analyzed the run-length coding in combination with context conditioning based on previously encoded bits of neighboring coefficients using Hilbert scan approach, which will give the efficient speed, that coding is compared with the SPIHT they achieved 0.1-0.2 DB high PSNR values of lena, the drawback of that approach is inferior RD performance, to overcome [32] that the paper [33] presents the sequences drawn from the scan in the dominant pass , it was turns out that self-similar curves scanning the dominant pass increaser the compression efficiency. That is a consequence of the correlation of direct neighbors in the wavelet domain. Its dependence can be better exploited by using groups of coefficients, similar to the SPIHT algorithm, then results will be very fast coding algorithm, which shows performance similar to the state-of-the-art coder SPIHT, but with lower complexity and small and fixed memory overhead.

V. N. Ramaswamy *et al* [34] approached the new algorithm based on wavelet based embedded zero tree algorithms., which is compared [32],[33]with the SPIHT and CALIC[29] with all aspects, this will improves the performance of compression algorithm after multilevel subband decomposition is performed, and they proposed the context modeling significance information based on the significance of previous threshold improves the performance of the compression algorithm he residue information does not have enough correlation to perform a prediction based on the accumulated prediction errors, a key concept in CALIC. It was found that threshold 32 was optimal for good compression efficiency. As the threshold is decreased to 16 and 8, the storage and computational complexity increases. J. Lin et al [84] proposed the algorithm for to reduce the distortion coding in low bit rate subband/wavelet coder using symmetric extension filter bank, which will give perfect reconstruction using FIR and IIR filter. The disadvantage of this method decomposition in the cyclic frequency domain might be that not all image sizes can be accommodated with the same efficiency. M. B. Martin *et al* [37] proposed the new multiwavelets packets, which has the desirable property such has orthogonality and symmetry, which will provide the best performance in the compression, here they introduce the techniques to improve the performance by decomposition iteration and zerotree based quantization for multiwavelet, and those methods were compared with the existing algorithm SPIHT and EZW. While the improved decomposition iteration gives uniformly better results, the performance gains of shuffling depend on the image content. Shuffling helps most images with more low-frequency content; images with more high-frequency content typically realize no significant performance benefit and in some cases, performance is degraded. However, performance decreases tend to be quite small whereas performance increases from shuffling are often quite significant. J. Reichel et al [40] proposes the integer wavelet transform (IWT) for embedded lossy to lossless image compression, compared to [5],[6] here DWT is the lifting scheme (LS) because it will provide the perfect reconstruction, nonlinear transform can be used, allowing efficient lossless compression as well.it is the alternative for DWT because its rate-distortion performances is similar and the differences can be predicted A model for the degradation of quality caused by the use of IWT. It is based on the hypothesis that the nonlinear rounding operation can be replaced by an additive white noise, to compute the impact of various noise sources on the reconstructed pixel, equivalent transfer functions were computed. The IWT can lead to much larger degradations than the DWT, especially for small quantization steps, i.e., small compression factor. However the differences in terms of visual quality are rather small regardless of the compression factor.

M. Grangetto et al [41] approached the design and implementation of an image transform coding algorithm based on the integer wavelet transform (IWT), here they proposed the selection of optimal factorizations of the wavelet filter polyphase matrix to be employed within the lifting scheme, compared to [40] which will provide efficient IWT implementation. The methods for the selection of the best factorization of wavelet filters within the LS framework are proposed and compared; the methods are based on the search for the minimally nonlinear iterated graphic functions associated to integer transforms, on the minimization of the number of lifting steps, and on the achievement of the closest-to-one normalization constant. Results are reported for a number of filters and test images and for both lossless and lossy compression, showing that the obtained IWT implementation achieve compression performance very close to the real valued DWT. A second aspect addressed is the evaluation of the effects of finite precision representation of the lifting coefficients and the partial results; the analysis has revealed that a very small number of bits can be devoted for the mantissa, with acceptable performance degradation.

Z. Liu et al [44] proposes the novel compression algorithm for chromosome image based on the ROI by performing the differential on chromosome ROI for decorrelration.it was used in commercial karyotype system code the entire image as whole wasting valuable chromosome ROI segmentation information while retaining much of the unwanted redundancy. Here lossless compress the chromosome ROIs, while lossy compressed the background and reconstructed the image with imperceptible difference, both at low bit rates, those results compared with the familiar coding LZW. It is very attractive for emerging applications like progressive image transmission in cytogenetic telemedicine and fast searching and browsing of chromosome and karyotype images. D. Wu et al [76] proposed a novel perceptually lossless coder to remove the visually irrelevant information which will provide better bpp compared to [44]. A. T. Deever et al [48] developed the algorithm to give more importance for the sign of the transform coefficients, sign coding was examined in detail in the context of an embedded wavelet image coder. In addition to they used intraband wavelet coefficients in a sign coding context model, a projection technique is described that allows nonintraband wavelet coefficients to be incorporated into the context model. At the decoder, accumulated sign prediction statistics are also used to derive improved reconstruction estimates for zero-quantized coefficients. These techniques are shown to yield PSNR improvements averaging 0.3 dB. A. T. Deever et al [46] proposed the technique for decreasing the first-order entropy of transform coefficients and improving the lossless compression performance of reversible integer wavelet [36] transforms and it was developed and used to predict a wavelet transform coefficient as a linear combination of other wavelet transform coefficients. That yields optimal fixed prediction steps for lifting-based wavelet transforms and unifies much wavelet-based lossless image compression. L. Wang et al.[90] proposed the Lossy-to-lossless image compression based on multiplier-less reversible integer time domain lapped transform to achieve compression ratio better than the JPEG2000 and JPEG-LS.

G. Menegaz et al [51] proposes the 3D encoding/2D decoding functionalities for medical data, the proposed 3-D/2-D multidimensional layered zero coding system provides the improvement in compression efficiency attainable with 3-D systems without sacrificing the effectiveness in accessing the single images characteristic of 2-D ones. The implementation of the transform by the lifting scheme[40] enables lossless functionalities, permits the in-place implementation, minimizes the run-time memory allocation, and reduces the computational complexity up to a factor 4. The set of subband images needed to reconstruct a given 2-D image depends on the length of the synthesis filters and the number of decomposition levels. The 2-D decoding mode is obtained by independently encoding each subband image. The amount of overloading of the bitstream in the different working modalities depends on many factors, like the dynamic range of the transformed coefficients, the decomposition depth, the statistics of the source and the availability of the PSNR scalability.

Z. Averbuch et al [54] proposed an efficient technique that generates a wide range of new biorthogonal symmetric wavelet transforms. This technique is based on the usage of discrete and polynomial interpolatory and quasiinterpolatory splines for the design of filters for the predict and update operations in lifting schemes [40] of the wavelet transform These are the linear phase filters which have flat frequency responses. By combining different designed filters for the predict and update steps, we can devise practically unlimited forms of wavelets which have a pre-determined number of vanishing moments that are as smooth as required. When transforms that are based on splines of higher orders were implemented. K. Peng et al [55] proposed the new algorithm based on based on a novel scheme of modeling and ordering in wavelet domain, "pixel classification and sorting (PCAS). PCAS, pixels to be coded are classified into several quantized contexts based on a large context template and sorted based on their estimated significance probabilities. The purpose of pixel classification is to exploit the intraband correlation in wavelet domain. Pixel sorting employs several fractional bit-plane coding passes to improve the rate-distortion performance. The PCAS algorithm will give excellent compression performance with either spatial or quality scalability at different complexity modes. Our new pixel classification and sorting method can be used to improve the performance of other embedded codes such as EBCOT and SPIHT.D.Wang et al [75] proposed the new wavelet transform is curvelet, which will perform edges and lines in the image pixel curves can be represented by small number of wavelet coefficients, compared to [25] ,it will give better performance in PSNR, Particularly efficient for images that contain sharp edges and can provide a PSNR gain of up to 1.67 dB for natural images compared with JPEG2000 and [40]. L. Li et al [89] presented the improvement of prediction error for quality of JPEG2000 model and it can able to provide the less than 1dB prediction error for 70% images with the compression ratio of 15% and less than 2 dB prediction error for 90% sample images with the better compression ratio compared to [79].

M. N. Do et al [56] proposed the new scheme of wavelet, this will be used in directional multiresolution analysis with countourlet transform, which will provide better PSNR than wavelet, here they constructed the a discrete-domain multiresolution and multidirectional expansion using nonseparable filter banks, in much the same way that wavelets were derived from filter banks. Here they shows the parabolic scaling and sufficient directional vanishing moments, contourlets achieve the optimal approximation rate for piecewise smooth functions with discontinuities along twice continuously differentiable curves. J. Hua, Z et al. [57] presented the embedded M-FISH image coding (EMIC), here the foreground objects or chromosomes and the background objects or images are coded separately by applying the integer wavelet transform first for critically sample to the foreground and background of the image., then to compress each object they generated the embedded bit stream that will allow continuous lossly to lossless compression of the foreground and background and This will performs better than the JPEG-LS and JPEG2000. Finally, the scalable lossy to lossless bitstream generated by EMIC is attractive for emerging applications such as telemedicine and fast browsing of medical image databases. The method proposed by I. F. Models et al [86] lossless biplane based method for efficient compression in micro array images. They have used the arithmetic coding driven by image independent multiplane finite context models, and it will produces the embedded bit stream that allows progressive lossy to lossless decoding, which will give the better result compare to earlier methods like JPEG2000, JPEG-LS and JBIG [57].this has advantage of reduce the complexity and reduced the size of the memory and decoding is fast.

R. Shukla et al [59] proposed the optimization of rate distortion (R-D) tree structured algorithms for piecewise polynomial images with polynomial boudries A good approximation of this class allows to develop good approximation and compression schemes for images with strong geometrical features and, as experimental results show, also for real life images, then improvement of about 1 dB was achieved over the state of the art image coder

(JPEG2000). This shows the potential of such geometry-based image coding also it will provide better PSNR and entropy as 0.15bpp for camera man image. J. Wei et al [60] proposed the lossy-to-lossless compression, to compress the background in medical image using by boundary artifacts are an inescapable consequence of the usual methods used to choose tile size and the type of symmetric extension employed in a wavelet-based image decomposition system. Here they developed a novel method to reduce the tile-boundary artifacts and also reduces the bit rate needed for mentioned PSNR in a compressed image. The method employs odd tile sizes rather than the conventional even tile sizes. Here they shown that, for the same bit rate, an image compressed using an odd tile length low-pass first (OTLPF) convention has significantly less boundary artifacts than an image compressed using even tile sizes. A. Alecu wt al [61] proposed the algorithm for new multidimensional wavelet-based L-infinity constrained scalable coding framework compared to [19], [25], [57] that generates a fully embedded L-infinity oriented bit stream and that retains the coding performance and all the scalability options of state-of-the-art L_2 oriented wavelet codecs .

C.-L. Chang et al [61] proposed the novel approach for light field compression that uses disparity compensated lifting for inter-view wavelet coding. The lifting structure integrates disparity compensation into wavelet coding and remains reversible. Reconstruction of the acquired views is free of the distortion caused by the irreversible resampling process. The proposed scheme also supports scalability in image resolution, viewpoint, and reconstruction quality, which will give the better PSNR and bit rate reduction up to 70%. Y.-W. Chang et al [63] proposed the algorithm for precompression quality control, thus truncation points [61] are chosen before actual coding by the entropy code, this algorithm minimizes bit rate at a given image quality. By estimating rate and distortion before coding, the truncation points are selected before coding. The image quality degrades about 0.1 0.3 dB on average compared with the PCRDO algorithm. V. Chappelier et al [67] proposed the new adaptive discrete wavelet transform based on the lifting scheme applied along an orientation map defined on a quincunx multiresolution sampling grid. The map is either coded using a quad tree optimized with a rate-distortion criterion. The oriented wavelets transform shows similar or better results than other oriented transforms [61], with a low complexity. C.-L. Chang et al [79] proposed the direction-adaptive DWT (DA-DWT) that locally adapts the filtering directions to image content based on directional lifting, DA-DWT is more effective than other lifting-based approaches. It will give a gain of up to 2.5 dB in PSNR over the conventional DWT for typical test images. M. B. Wakin et al.[74] approached the new technique to enables new type of quadtree pruning for piecewise smooth images, using zerotrees in uniformly smooth regions and wedgeprints in regions containing geometry, using this technique they developed the prototype image coder that has near optimal asymptotic R-D performance, which will give better MSE, PSNR and visual quality compared to [32], [34] earlier methods. Z. He [81] proposed the a nonlinear geometric transform, called peak transform (PT), for efficient image representation and coding, which can able to convert the high frequency signal in to low frequency signal, to make easier compress and also its extends to wavelet based decomposition compared to [40], [60] the high frequency band reduced up to 60% if peak transform applied. H. F. Ates et al [88] presented the wavelet based efficient coding algorithm using spherical coding algorithm, this coder uses local energy as a direct measure to differentiate between parts of the wavelet subband and to decide how to allocate the available bitrate for smaller size of windows, which will achieve better energy compaction, which will produce better PSNR.K.Ezhilarasan et.al [91] proposed the fast fractional wavelet transform combined with spiht algorithm, which gives the better PSNR and compression ratio with the scale factor of 0.91and which gives better computation speed also compared to the conventional wavelet transform.

3. Proposed Methodology

Here the author proposes the fast efficient lifting wavelet transform using pipelining, which eliminates the multiplier operation and utilizes less memory with the less registers were used for transposed unit and instead of conventional adder, The figure 3 shows that the proposed architecture and internal structure of DWT 5/3 filter uses the modified conventional carry skip adder, which reduces the critical path in the pipelining processing compared to the Fast fractional wavelet transform, here we reduce the hardware complexity.

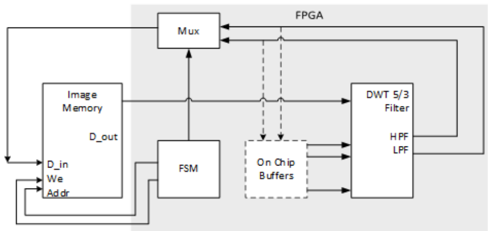

Fig. 3 Proposes Architecture

4. Conclusion

This paper presents that various methods to perform the image compression in real time processing, compare to all the methods transform based methods will give the better expected resulted than other methods, compare to convolution based wavelet transform, the lifting scheme utilize the less hardware complexity and also efficient, which reduces the hardware complexity and reduce the critical path delay and that will be implemented in the FPGA.

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