An Efficient Technique of Lossless Data Compression

Megha S. Chaudhari , S.S.Shirgan

***Abstract*— We present a new method for lossless image compression that gives compression comparable to JPEG lossless mode with about five times the speed. Our method, called ELICS, is based on a novel use of two neighboring pixels for both prediction and error modeling. For coding we use single bits, adjusted binary codes, and Golomb Rice codes. For the latter we present and analyze a provably good method for estimating the single coding parameter. Efficient, lossless image compression system (ELICS) algorithm, which consists of simplified adjusted binary code and Golomb–Rice code with storage-less k parameter selection, is proposed to provide the lossless compression method for high-throughput applications. The simplified adjusted binary code reduces the number of arithmetic operation and improves processing speed. According to theoretical analysis, the storage-less k parameter selection applies a fixed value in Golomb–Rice code to remove data dependency and extra storage for cumulation table.**

***Index Terms*— Binary adjusted coding,Golomb-Ricecoding, Intensity distribution, lossless data compression, predictive coding, wavelet transform.**

I. INTRODUCTION

Due to the great innovation of display and information technology, the stringent requirement of data capacity is drastically increased in human life. This trend makes a significant impact on storage and communication evolution. The data compression technique is extensively applied to offer acceptable solution for this scenario, some images like satellite images or medical images have very high resolution. Such high resolution images have large file size. Computation time required to process such high quality images is more. Hence compression of images and video has become need of hour. The image can be compressed using lossy or lossless compression techniques. In the lossy image compression technique, the reconstructed image is not exactly same as the original image.

The lossless image compression can remove redundant information and guarantee that the reconstructed image is without any loss to original image. Different image compression techniques are suggested by the researchers, but the technique with high data compression with low loss is always preferred. Because of the advance- ment in Internet, world has come very close and can afford and avail the services such as medical, tourism, education etc., remotely. Data compression is the key in giving such fast and efficient communication. It has made large impact on service sector to provide best services to all sections of society. High code efficiency is measurement parameter for performance of data compression system.

The dictionary-based algorithm exploits almost identical mapping relation- ship; prediction technique is utilized to improve coding efficiency. Prediction- based algorithms apply prediction technique to generate the residual, and utilize the entropy coding tool to encode it. Many methods, including fast, efficient, lossless image compression system (FELICS) [4], context-based, adaptive, lossless image coding (CALIC) [5] and JPEG-LS, have been extensively developed in this field. Among these methods, the JPEG-LS presents better performance [6] and is further adopted as lossless/near-lossless standard, but it possesses serious data dependency and complex coding procedure that limits the hardware performance in high-throughput applications. The fast, efficient, lossless image compression system (FELICS) algorithm, which consists of simplified adjusted binary code and Golomb-Rice code with storage-less k parameter selection, is proposed to provide the lossless compression method for high-throughput applications. The simplified adjusted binary code reduces the number of arithmetic operations and improves processing speed. According to theoretical analysis, the storage-less k parameter selection applies a fixed k value in Golomb-Rice code to remove data dependency and extra storage for cumulation table. Besides, the colour difference pre-processing is also proposed to improve coding efficiency with simple arithmetic operation.

II. LITERATURE REVIEW

Using present techniques, we can compress image either by using lossy or loss- less compression algorithms. For lossy compression technique, many sophisticated standards have been intensively developed such as JPEG and JPEG 2000 for still image, and MPEG-4 and H.264 for multimedia communications and high-end video applications, respectively. Many articles put more effort on related VLSI architecture designs [1]. Therefore, both algorithm and hardware implementa- tion have attracted massive research effort for the evolution of lossy compression technique. Lossless compression can remove redundant information and guaran- tee that the reconstructed procedure is without any loss to original information. This can ensure that the decoded information is exactly identical to original in- formation. According to the coding principle of lossless compression technique, it can be categorized into two fields: dictionary-based and prediction-based. In dictionary-based, frequently occurring and repetitive

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Megha S. Chaudhari, Dept.of Electronics & Telecommunication, N.B.Navale college of engineering, Solapur,India
S.S.Shirgan, Dept.of Electronics & Telecommunication, N.B.Navale college of engineering, Solapur,India

patterns are assigned to a shorter codeword. The less efficient codeword is assigned to the others. Based on this principle, the codeword table should be constructed to provide the fixed mapping relationship. Many famous methods, including Huffman coding [2], run length coding , arithmetic coding, and LZW[3], have been widely developed, and some of them are further applied in lossy compression standards. The FELICS [4], proposed by P. G. Howard and J. S. Vitter in 1993, is a lossless compression algorithm with the advantage of fast and efficient coding principle. Furthermore, FELICS presents competitive coding efficiency in com- parison with other sophisticated lossless compression algorithms [7].

III. Problem Statement

A. Present Technique:

We can compress Image either Lossy or Lossless compression algorithm using JPEG and JPEG 2000 technique.

Many methods, including efficient lossless image compression system , context-based, adaptive, lossless image coding (CALIC) and JPEG-LS, have been extensively developed in this field. Among these methods, the JPEG-LS presents better performance and is further adopted as lossless/near-lossless standard, but it possesses serious data dependency and complex coding procedure that limits the hardware performance in high-throughput applications. The efficient lossless image compression system algorithm, which consists of simplified adjusted binary code and Golomb rice code.

B. Title of work:

“Implementation and Analysis of Efficient Lossless Image Compression Algorithm Using Binary Adjusted Coding and Golomb-Rice Coding Technique”

C. Proposed Work:

Applying image The Wavelet Transform on the Image:

For applying wavelet transform on the MATLAB Wavelet Toolbox can be used.

Applying ELICS technique on the pixels:

For applying ELICS technique on the pixels we can develop a MATLAB program by considering following mathematical formulation.

Applying Adjusted Binary Coding (ABC) on in-range pixels:

Again adjusted Coding technique on the for applying Binary pixels we can develop a MATLAB program by considering mathematical formulation.

Applying Golomb-Rice coding on out of range Pixels:

For applying Binary adjusted Coding technique on the pixels we can develop a MATLAB program by considering mathematical formulation. This will be faster and efficient than the existing JPEG and JPEG-2000 techniques.Development of the proposed algorithm using MATLAB. JPEG uses Discrete Cosine transform (DCT) and JPEG-2000 uses Wavelet Transform. By applying the adjusted binary code and golomb rice code techniques on wavelet coefficients faster and efficient compression algorithm can be achieved.

D. Description of the method

Proceeding in raster-scan order, we code each new pixel P3 using the intensities of the two nearest neighbors of P that have already been coded; except along the top and left edges, these are the pixel above and the pixel to the left of the new pixel (see Figure 2). We call the smaller neighboring value L and the larger value H, and we define to be the difference H ≤ L. We treat _ as the prediction context of P, used for code parameter selection. The idea of the coding algorithm is to use one bit to indicate whether P is in the range from L to H, an additional bit if necessary to indicate whether it is above or below the range, and a few bits, using a simple prefix code, to specify the exact value. This method leads to good compression for two reasons: the two nearest neighbors provide a good context for prediction, and the image model implied by the algorithm closely matches the distributions found in real images. In addition, the method is very fast, since it uses only single bits and simple prefix codes.

IV. Methodology:

Most lossless image compression methods consists of four main components a selector, a predictor, an error modeler and a statistical coder.

Pixel Selector: A selector is used to choose the next pixel which is to be encoded, from the image data.

Intensity Predictor: - A predictor is used to estimate the intensity of the cur- rent pixel depending on the intensities of the two reference pixels Error modeler. It is used to estimate the distribution of the prediction error.

Statistical coder: It is used to code the prediction error using the error distribution. By using an appropriate pixel sequence we can obtain a progressive encoding, and by us- ing sophisticated prediction and error modeling techniques in conjunction with arithmetic coding we can obtain state-of-the-art compression efficiency. These techniques are computation intensive. The (ELICS) is a simple system for lossless image compression that runs very fast with only minimal loss of compression efficiency [7]. In this algorithm raster-scan order is used, and a pixel’s two nearest neighbors are used to directly obtain an approximate probability distribution for its intensity, in effect combining the prediction and error modeling steps.

Fig 1: Block Diagram of data flow

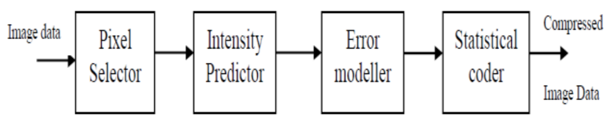
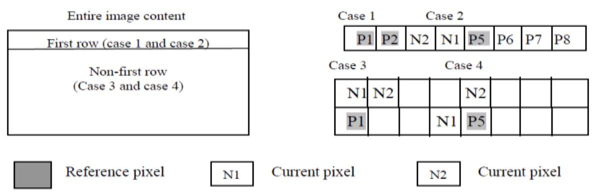


Fig.2 Illustration of prediction template in FELICS



FELICS utilizes two reference pixels around current pixel to yield the predic- tion template, and it can be divided into four cases. In case 1, since surrounding reference pixels are not available for the first two pixels, P1 and P2, both current pixels are directly packed into bit stream with original pixel intensity. For case 2, successive pixels, N1 and N2, are regarded as reference pixels for current pixel P5. For non-first row, cases 3 and 4 clearly define the relationship between cur- rent pixel and reference pixels. Between N1 and N2, the smaller reference pixel is represented as L, and the other one is H. As in Fig.4, the intensity distribution model is exploited to predict the correlation between current pixel and reference pixels. In this model, the intensity that occurs between L and H is with almost uniform distribution, and regarded as in-range. The intensities higher than H or smaller than L are regarded as above range and below range, respectively. For in-range, the adjusted binary code is adopted, and GolombRice code is for both above range and below range [7].

Flow chart

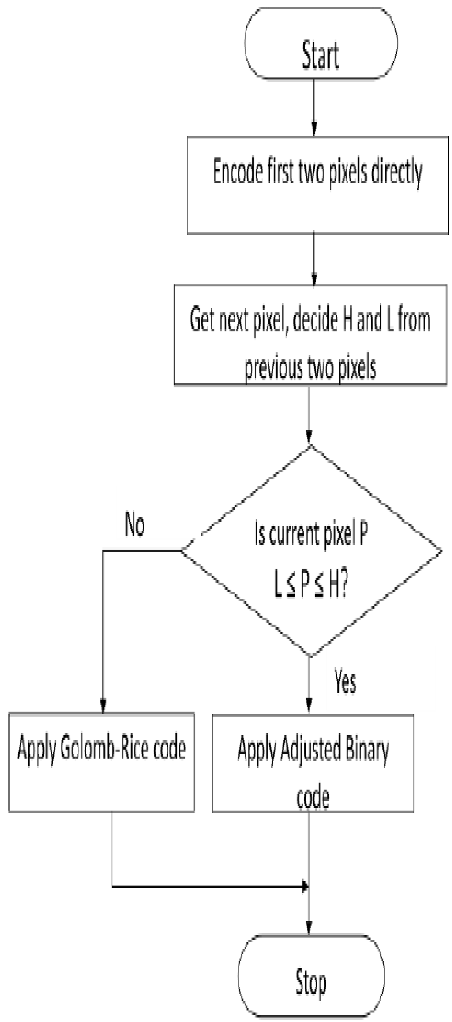


Fig.3 Flowchart for the FELICS Algorithm

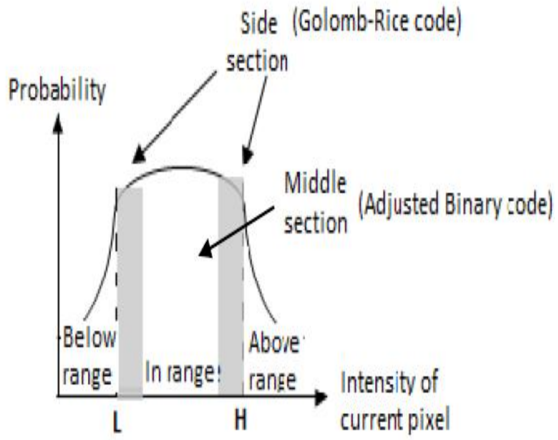


Fig.4 Probability distribution model in FELICS

Fig. 4 shows that the adjusted binary code is adopted in in-range, where the intensity of current pixel is between H and L. For in-range, the probability distribution is slightly higher in the middle section and lower in both side sections. Therefore, the feature of adjusted binary code claims that the shorter codeword is assigned to the middle section, and longer one is assigned to both side sections. To describe the coding flow of adjusted binary code, the coding parameters should be first declared as follows:

$$\begin{cases} \text{delta} = H - L \\ \text{range} = \text{delta} + 1 \\ \text{upper\_bound} = \lceil \log_2(\text{range}) \rceil \\ \text{lower\_bound} = \lfloor \log_2(\text{range}) \rfloor \\ \text{threshold} = 2^{\text{upper\_bound}} - \text{range} \\ \text{shift\_number} = \frac{(\text{range} - \text{threshold})}{2}. \end{cases}$$

The adjusted binary code takes the sample of P-L to be encoded, and range indicates that the number of possible samples should be encoded for a given delta. The upper bound and lower bound denote the maximum and minimum number of bits to represent the codeword for each sample, respectively. Particularly, the lower bound is identical to upper bound, while the range is exactly equal to the power of two. The threshold and shift number are utilized to determine which sample should be encoded

Golomb-Rice Code For both above range and below range, the probability distribution sharply varies with exponential decay rate, and the efficient codeword should be more intensively assigned to the intensity with high probability. There- fore, Golomb-Rice code is adopted as the coding tool for both above range and below range. With Golomb-Rice code, the codeword of sample x is partitioned into unary and binary parts Golomb-Rice code: - Unary part: floor(x/2k) Binary part: x mod 2k where k is a positive integer.

The entire codeword is concatenated with unary part and binary part, and one bit is inserted between both for identification. Therefore, the Golomb-Rice code is a special case of Golomb code, and its k parameter, exactly equal to power of 2, is efficient for hardware implementation. The selection procedure of k parame- ter induces serious data dependency and consumes considerable storage capacity. The resulting compressor runs about five times as fast as an implementation of the lossless mode of the JPEG proposed standard while obtaining slightly better compression on many images [4].

Formal description of algorithm

To encode an image, we output the _rst two pixels without coding, then repeat the
following steps:
1. We select the next pixel P and _nd its two nearest neighbors N1 and N2.
2. We compute L = min(N1;N2), H = max(N1;N2), and _ = H □ L.
3.
(a) If L ≤ P ≤H, we use one bit to encode IN-RANGE; then we use an
adjusted binary code to encode P □ L in [0; Δ].
(b) if P < L, we use one bit to encode OUT-OF-RANGE, and one bit to
encode BELOW-RANGE. Then we use a Golomb-Rice code to encode the
non-negative integer L - P - 1.
(c) if P > H, we use one bit to encode OUT-OF-RANGE, and one bit to
encode ABOVE-RANGE. Then we use a Golomb-Rice code to encode the non-negative integer P -H -1.
The decoding algorithm involves simply reversing step 3, decoding the in-range/out-
of-range and above-range/below-range decisions, branching accordingly, and adjust-ing the decoded numbers to obtain the value of P.

V. Conclusion

The proposed algorithm uses the Adjusted BinaryCoding which requires minimum two bits per pixel for in range and Golomb-Rice coding for out range. Since for most of the pixels Adjusted Binary Coding will be used so the compression ratio will be very high. Also due to use of ELICS technique the algorithm will be faster and efficient.

VI. Results Analysis

Image Quality Parameters
For comparing the images obtained from the three techniques we have considered various image quality parameters such as Compression Ratio (CR), Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), Normalized Cross-Correlation (NCC), Average Di_erence (AD), Structural Content (SC) and Normalized Absolute Error (NAE) [7]. Here for calculating various image quality parameters original image matrix and compressed image matrix are used. I1(m; n) indicates an element of original image matrix and I2(m; n) indicates an element from compressed image matrix. Also M and N indicate the number of rows and columns of image matrix. For calculating the image quality parameters the dimensions of original and compressed images must be same.

VII. Results

Here, a same image is compressed by three different image compression tech-niques. First technique consists of FELICS algorithm, second technique consists of JPEG. The third technique is the proposed technique which consists of the DWT technique followed by the FELICS algorithm.

This experiment is carried out on different class of images these images are taken the performance of these techniques is compared on the basis of various image quality measures such as Compression Ratio (CR), Bits per pixel, Signal to Noise Ratio (SNR), Inefficiency, Throughput.

Here, different types of images are used. Standard images like Lenna, Baboon, Man, Woman,Bridge boat. The Lenna image contains a nice mixture of detail, at regions, shading, and texture that do a good job of testing various image processing algorithms. The Baboon image has details and texture information. The Bridge and Boat images have mixture of detail, edges and shading.

Figure 1 : Lenna image compressed using (a) FELICS (b) JPEG (c) 2-level DWT+FELICS (d) 3-level DWT+FELICS

Table 1

Parameter	FELICS+ DWT	FELICS Adjusted	JPEG	Compress
original size (kb)	35.7	38.6	156	316
compression ratio	9.13	1.72	1.72	1.14
Bits per pixel	0.87	4.65	4.65	7.01
Inefficiency	6.15	41.9	44.28	42
Throughput	314.06	83.8	32.4	81.9
SNR	10.39	10.21	15.23	12.8

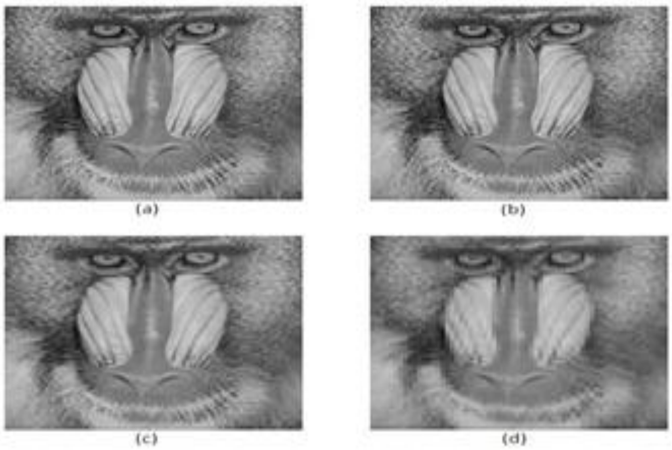


Figure 2 Baboon image compressed using (a) FELICS (b) JPEG (c) 2-level DWT+FELICS (d) 3-level

Parameter	FELICS+DWT	FELICS Adjusted	JPEG	Compress
original size (kb)	60	74	157	337
compression ratio	5.62	2.18	2.15	1.63
Bits per pixel	1.422	3.6	3.72	4.92
Inefficiency	2.53	44.60	7.1	34.9
Throughput	230.0	88.9	17.1	69
SNR	11.4	11.3	14.7	12.5

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Megha S. Chaudhari, Dept.of Electronics & Telecommunication, N.B.Navale college of engineering, Solapur,India

S.S.Shirgan, Dept.of Electronics & Telecommunication, N.B.Navale college of engineering, Solapur,India