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Implementation of Lossless Image Compression Analysis Using PCLZ Algorithm with Multiwavelet Transform

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Abstract*: Image compression is the method of encoding less information than original bits of representation and to aid this fact, various associated methods are being reviewed. In this paper author(s) proposes an improvement over Pixel Compressed Lempel-Ziv (PCLZ) a compression algorithm, by employing a new technique that uses multiwavelet decomposition (MWD). The loss-less compression applications are used for quality data transfers, social media, medical imaging, and digital camera technology emerge. In previous loss-less image compression techniques effort to find the smallest specific pixel intensity levels of image quality, while the PCLZ compression used the maximum levels of LL band to compress the image. Moreover, the reconstruction of the image by using three-level Daubechies wavelet decomposition creates a number of levels of gray vector matrixes. The proposed method results in good quality metrics for the compress ratio (CR), peak signal to noise ratio (PSNR), mean square error (MSE) and bits per pixels (BPP) to exhibits a large set of different standard test images.

Index Terms*: Data compression, Daubechies transformation, discrete wavelet transformation, Pixel-based compression, Lossless image coding.

I. INTRODUCTION

Dynamic dictionary-based compression is normally adopted to represent one or the other types of lossless data compression calculations which utilize a dictionary reference that begins from a foreordained state, however, it esteems during the encoding or decoding process. A standout amongst the most understood dynamic dictionary based compression calculations is a Lempel-Ziv-Welch algorithm which was made as an alteration of the BITLZ78 algorithm [5]. It is a universally useful compression algorithm as it can work with a data. The dictionary that is utilized as a part of LZW stores set of codes and series of characters [3], [4]. At the underlying condition, just strings of length one are put away (ASCII characters) in the dictionary, as it may during the encoding procedure strings that have not been experienced beforehand are added to the dictionary.

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Compression is accomplished by supplanting the strings with the codes that are related to them [10]. Additionally, decompression is accomplished by replacing sets of codewords with their related strings [1]. One of the primary factors that should be considered while actualizing LZW compression is the measure of bits that ought to be distributed to each codeword [2], which decides the measure of special codewords that can be located away in the word reference at any given time [3]. The disadvantage of expansive word references is bigger than the dictionary which is of more space each codeword requires. In an embodiment, the long codeword can diminish the compression ratio. The proposed method works better than existing schemes coding digital maps and also provide progressive coding [8].Consequently, the strategy to oversee and revive the word reference after it turns out to be full of special interest. One of the key factors that can decide the achievable compression proportion is the dictionary size ought to be and how it ought to be taken care of after it turns out to be full. For a dictionary reference that can store 'n' unique indexes, each record will take up $\log2_n$ bits. Recently it was specified that compressed data is a gathering of indexes. In this manner, the bigger dictionary is of more space which each list requires, thus can bring about a bigger compressed document and littler compression proportion. This implies constraining the dictionaries estimate is essential to a specific end goal to accomplish more efficient compression. Integer Multi wavelet Transform (IMWT) with deflate encoding techniques for lossless image compression has presented [9] and applied multi wavelet coefficients for run-length and magnitude set coding which are used [12]. In addition, fast orientation prediction-based DWT is also used to improve coding performance and to reduce computational complexity by designing a new orientation map and orientation prediction model for high-spatial-resolution remote sensing images [14]. A standout amongst the most utilized strategies in taking care of a word dictionary is known as dictionary reset (DR). As the name itself specifies that, each time the dictionary reference turns out to be full, it is re established to its underlying state in which it stores just a single length strings. For the most part, strategies that can expel occasionally utilized sections while keeping the successive ones, more often than not accomplishing higher compression ratio [13], and a portion of the existing techniques which are least recently used (LRU) and least frequently used (LFU). Hybridization of empirical wavelet transform (EWT) along with DWT has been used for compression of the ECG signals [15]. As the image size is efficient, the compression ratio tends to the final optimal (entropy rate) value.

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The architectural structure of the paper is as follows: Section I begins with a brief summary of data compression schemes. In Section II of the paper, Lempel-Ziv compression and its enhancement in the form of multiwavelet transform is reviewed along with the block diagram. Proposed algorithm, Pixel Compression Lempel-Ziv technique and its enhancement discussed in Section III. Section IV presents the simulation results and followed by the conclusion in Section V.

II. RELATED WORK

A. Lempel-Ziv compression

Lempel-Ziv (LZ) is a compression based strategy. It maps a variable number of pixels to a fixed length code. The algorithm works by looking over the in sequence string to compress only binary data and low-resolution images. At the point when such a string is discovered, the index for the string without the last quality (i.e., the longest substring information position) is improved from the dictionary and sent to output vector, and the new string is added to the dictionary with the following access code. The input information [6] character is then utilized as the following beginning stage to filter the substrings. Progressively longer strings are enlisted in the dictionary and made accessible for resulting encoding as information. The calculation mechanism is best on information with efficient designs, so the original parts of an image will see non important dictionary. As the image measure develops, be that as it may, the weight information tends asymptotically to the eventually ideal (entropy rate) value [7]. This algorithm works similar to LZW method in the sense that when the information becomes full, it is decomposed from a single level to multiple levels with minimum to maximum information in total data matrices. However, unlike the LZW implementation, each dictionary has two values minimum data checking (MDC) and a number of maximum information (NMI). Pixel compression is N(t) is calculated for each block as: N(t)=N(0). e−λt+MDC, where N(0) is the initial value, λ is transformation rate, t is current time and NMI is equal to a number of maximum information calculation.

B. Multiwavelet transform

Multiwavelet transform with collection 'g' can be written by a vector information $\Phi(t) = [\Phi_1(t), \Phi_2(t)....\Phi_g(t)]$, the set of LPF functions and $\Psi(t) = [\Psi_1(t), \Psi_2(t).... \Psi g(t)]$, the set of HPF functions [1]. When g= 1 then it forms a scalar wavelet transform. The multiwavelet transformation consists of low pass and high pass bands which are optimized for energy.

$$\phi(t) = \Sigma_k Z_k \phi(2t-k) \quad (1)$$

$$\Psi(t) = \Sigma_k Y_k \Psi(2t-k) \quad (2)$$

Where Z_k, Y_k is the low-pass and high-pass multiwavelet coefficients respectively with multi-wavelets there are additional degrees of liberty to design the system. For immediate possession of orthogonality, short support, proportion and high estimate order of pixels is possible in multiwavelet system.

C. Daubechies wavelet decomposition

Both of scaling sequence and wavelet sequence like low-pass and band-pass filter using general representations of scaling of orthogonal multiwavelet transform with approximate order of higher pass bands A. $P_A(X) = 2^{1-A}(1+Z)^A$ where, Z is co-efficient of wavelet.

$$P_A(X) = \Sigma_{k=0}^{A-1}(\mathrm{f}_x \mathrm{f}_y)2^{-x}\,\mathrm{X}^y \quad (3)$$

Where '*A*' is higher pass bands, f_x , f_y are vector coefficients, *X* is total vector matrix, *x* is constant variable .

D. Proposed technique

In the proposed method, the original image is pre processed and to remove unwanted pixel intensity values, the image is transformed using Multiwavelet transform for compressing the image and the compressed image is decomposed by the inverse multiwavelet transform. The encoding is done with Pixel Compression Lempel-Ziv Technique (PCLZ), as shown in the Fig. 1.

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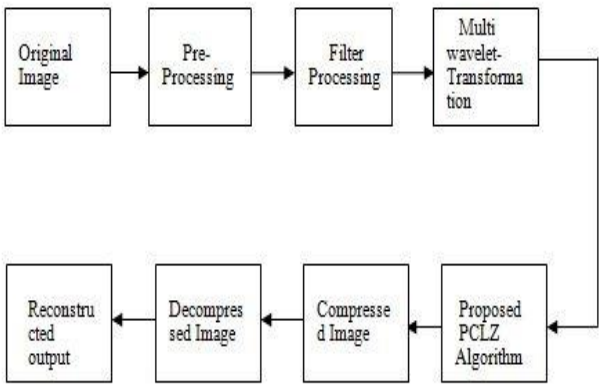

Fig. 1 Proposed Block Diagram of Image Compression Technique

III. PROPOSED PIXEL COMPRESSION LEMPEL-ZIV TECHNIQUE (PCLZ) AND ITS ENHANCEMENT

A. Proposed Algorithm

Step 1: The proposed lossless compression technique is to apply original gray level (*MXN*) input image and foreword optimize the Pre-analysis data matrices.

$$\vartheta I_x = \|\max\|\{(\mathrm{f}_x,\mathrm{f}_y),[\mathrm{W}\times\mathrm{H}]\} \quad (4)$$

Here I_x is input matrix, ϑ is type of matrix, f_x, f_y are collection of matrixes, *W* is image width and *H* is height.
Step 2: In the median filtering works, the pixel intensity values are checked from neighborhood window matrix values which are ranked accordingly, and the middle pixel intensity value (the median) becomes the output value for the pixel value underestimation.

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$$\xi y = \| abs(p),[mn] \| \quad (5)$$

Where y is the output data matrix, ξ is unwanted information, p is the input data matrix, and *mxn* is the size of the neighborhood information of total matrix.

Step 3: In multiwavelet transformation different levels are decomposed into four sub-bands i.e. LL, LH, HL, and HH. MWT is divided into three levels of transformation by using Daubechies [11].

$$W_{\varphi}(j_o,k) = \frac{1}{\sqrt{M}} \Sigma_V\, f(w)\varphi_{j,k}(x)^{*}1D \quad (6)$$

$$W_{\psi}(j_o,k) = \frac{1}{\sqrt{M}} \Sigma_k\, f(w)\psi_{j,k}(x)^{*}1D \quad (7)$$

Where f(w), $\varphi_{j,k}(x)$ and $\Psi_{j,k}$ (x) be functions of discrete variable V=0,1, 2,…,M-1. Generally we let j_0= 0 and choose M to be a power of 2 (i.e., $M=2^J$) so that the summations in equations (3)and (4) are executed over x=0, 1, 2,…,J-1, and k=0,1,2,…,2^J-1. 1D is Daubechies of single level transformation it will be varying 2D, 3D…etc.

Step 4: Pixel compression Lempel-Ziv (PCLZ) is calculated in minimum information to maximum information by the same group of neighborhood pixels.

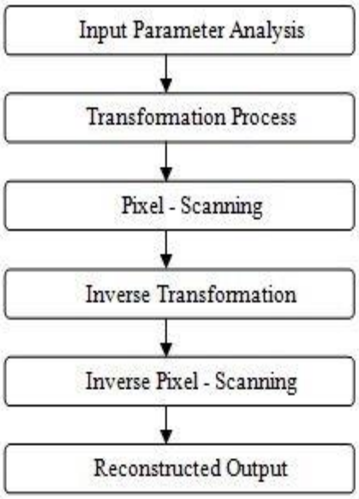

Fig. 2 Data flow model of proposed algorithm

Step 5: Transformation is to separate one condition to another condition of total pixel intensity values. Apply the pixel scanning in the top to bottom of the total matrix and apply same procedure in reverse process.

$$x_v^{'} = v_o + \Sigma_{i=1}^{j} v_n \cos(2\Pi nt \,|\, \tau) + \Sigma_{n=1}^{N} b_n \sin(2\Pi nt \,|\, \tau) \quad (8)$$

$$x_c^{'} = c_o + \Sigma_{i=1}^{j} c_n \cos(2\Pi nt \,|\, \tau) + \Sigma_{n=1}^{N} d_n \sin(2\Pi nt \,|\, \tau) \quad (9)$$

Where: τ is the number of steps needed for transformation with time v_n, c_n, d_n, b_n coefficients values of transformed matrixes and scanning matrixes. x_v', x_c' which are output vector matrixes of minimum level and maximum levels.

Step 6: The reconstruction of output image is more efficiently compressed compared to the original matrix. In reconstructed matrix, there are proper changes compared to the original image. The efficiency of the algorithm is described below statistically modeled and evaluated as follows.

In standard test images, it produces more efficient metric values compared with existing methods. The main aim of the survey was to compare the compression rates of the different algorithms with Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), Maximum Error (MAXERR), Structural Similarity (SSIM), and Compression Ratio (CR). In every case, all metric values were calculated and results are shown in Table I to IV.

MSE value and PSNR values are calculated as per Eq. (10) and (11) respectively, where f_x is output vector and f_y is input vector.

$$MSE = \| \Sigma_{i=0}^{N}(f_x)\Sigma_{j=0}^{M}(f_y) \times [M \times N] \|^{\wedge 2} \quad (10)$$

$$PSNR = 10 \times \log_{10}(f_x - f_y) / MSE \quad (11)$$

$$SSIM(a,b) = \frac{(2\mu_a\mu_b + c_1)(2\sigma_{ab} + c_2)}{(\mu_a^{\,2} + \mu_b^{\,2} - c_1)(\sigma_a^{\,2} + \sigma_b^{\,2} - c_2)} \quad (12)$$

Where $\mu_a\mu_b$ is the average value of 'a 'and 'b', σ_a^2 σ_b^2 are the variance of a, b and c_1 and c_2 are the variables.

MAXERR: The maximum absolute squared deviation of the data from the approximation.

CR: It is maximum number of original bits divides a maximum number of result bits.

IV. SIMULATION RESULTS AND ANALYSIS

The performance of MWD for lossless compression of images and the transform coefficients are coded with Pixel Compression Lempel-Ziv Technique (PCLZ). The simulation has been done using MATLAB tool on various images and the MSE, PSNR, MAXERR, and CR values have been obtained.

A. Results of Reconstructed Images

Fig. 3 Test images of Gold hill, Cameramen, Lena, and Lake (a) Original image (b) 3-D MWD Frame (c) Compressed image (d) Reconstructed image

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Lossless reconstructed images for standard test images of 3 –D MWD frames, compressed and reconstructed images are illustrated in Fig. 3. The simulation has been done using image compression on various images and the MSE, CR,MAXERR and PSNR values have been obtained, the major description can be observed from Table I, II, III and IV.

Table I .Shows the metric values of Test image of Gold hill with size 256 x 256

Encoding levels/ Parameters	Level 1	Level 2	Level 3
PSNR	65.67	65.80	65.93
MSE	0.0044	0.0040	0.0043
MAXERR	3.26	3.77	5.01
SSIM	0.355	0.351	0.347
CR	1.17	1.19	1.21
BPP	6.37	6.35	6.31

Table II. Shows the metric values of Test image of Cameraman with size 256 x 256

Encoding levels/ Parameters	Level 1	Level 2	Level 3
PSNR	66.33	66.46	66.59
MSE	0.0038	0.0037	0.0037
MAXERR	3.15	4.78	5.54
SSIM	0.350	0.347	0.345
CR	1.32	1.34	1.36
BPP	5.46	5.45	5.44

Table III. Shows the metric values of Test image of Lena with size 256 x 256

Encoding levels/ Parameters	Level 1	Level 2	Level 3
PSNR	65.50	65.63	65.76
MSE	0.0046	0.0045	0.0045
MAXERR	3.363	4.160	5.033
SSIM	0.356	0.357	0.358
CR	1.19	1.20	1.22
BPP	5.75	5.69	5.65

Table IV. Shows the metric values of Test image of Lake with size 256 x 256

Encoding levels/ Parameters	Level 1	Level 2	Level 3
PSNR	65.93	66.06	66.19
MSE	0.0042	0.0041	0.0041
MAXERR	3.23	4.16	4.82
SSIM	0.368	0.370	0.372
CR	1.04	1.06	1.08
BPP	5.47	5.44	5.41

The above mentioned tables represent the calculation of PSNR, MSE, MAXERR, SSIM, CR, and BPP values of results for reconstructed standard test images using the lossless method.

V. CONCLUSION

The procured results are optimized and calculated the different ways of development in PCLZ algorithm. In particular, MWD may be an effective tool to manage and invigorate the LZW dictionary. The proficient compression ratio is higher than the traditional techniques similar to Lempel-Ziv and lossy. However, the compression and decompression time is reduced by using MWD. It was shown that pixel length significantly affects the consummate compression ratio. In addition, different images may require different codeword lengths with an order to achieve an optimal compression ratio. In PCLZ method, efficient lossless compression compared existing methods to depict the proliferation of better metric values like PSNR, MSE and Compress Ratio; moreover, the experimental result shows the proposed technique of better performance.

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