Spatial Domain Lossless Image Data Compression

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Abstract -- Digital image compression deals with methods for reducing the total number of bits required to represent an image. This can be achieved by eliminating various types of redundancy that exist in the image dataset. Lossless image compression techniques preserve the information so that exact reconstruction of the image is possible from the compressed data. Major lossless or error free compression methods like Huffman, arithmetic and Lempel-Ziv coding do not achieve great compression ratio. It is necessary to preprocess the images in order to reduce the amount of correlation among neighboring pixels, to improve compression ratio further. Keeping this in view this works intend to focus on a comparative investigation of various lossless image compressions in spatial domain techniques and proposed an algorithm which achieves more compression ratio. The proposed algorithm is divided into two phases. In first phase the color image is divided into RGB plane and where each plane is divided into no. of blocks which uses variable bits to store each block pixels. Calculation of variable bits is dependent on pixel values of each block. In the second phase output of the first phase is supplied to LZW algorithm. The advantage of proposed scheme is that it uses integrated approach which depends upon pixels correlation within a block and LZW algorithm. The output of proposed scheme provides better compression than TIFF, GIF and PNG formats for color image.

Indexed Terms -- LZW, RGB, Inter-pixel.

I. INTRODUCTION

In recent years, the development and demand of multimedia product grows increasingly fast, contributing to insufficient bandwidth of network and storage of memory device. Therefore, the theory of data compression becomes more and more significant for reducing the data redundancy to save more hardware space and transmission bandwidth. In computer science and information theory, data compression or source coding is the process of encoding information using fewer bits or other information-bearing units than an encoded representation [1,2]. Compression is useful because it helps reduce the consumption of expensive resources such as hard disk space or transmission bandwidth.

The objective of image compression is to reduce the redundancy of the image and to transmit and store data in an efficient form. Compressing an image is significantly different than compressing raw binary data. The general purpose of compression programs can be used to compress images, but the result is less than optimal. This is because images have certain statistical properties which can be exploited by encoders specifically designed for them [4,7]. Also some of the finer details in the image can be sacrificed for the sake of saving a little more bandwidth and storage space.

II. BACKGROUND STUDY

In spatial domain separating the image into blocks, preprocessing it and finding the largest difference pixel (LDP) value of a block to recoding the block gives better result for gray scale image [20]. This technique achieved better results in some extents while failed to overcome the existing mechanisms in other times. However, easy and straightforward computation of this technique reduces computational time significantly and achieved somewhat equal compression ratio as compared to the existing mechanism. Lossless image compression in spatial domain in which variable bits is dependent on pixel values of each block is depending on pixel correlation within a block [23]. Algorithm related to this concept gives better compression/decompression efficiency as compared to other techniques. Image compression/decompression performing in two phase gives better result [25]. The proposed scheme consists of two phases namely, the prediction phase and quantization phase. In the prediction phase, a hierarchical structure among pixels in the image is built. Following the constructed hierarchical structure, the neighboring pixels are utilized to predict every central pixel. The prediction scheme generates an image map which indicates the prediction errors. The structure of the resulting image map is very similar to the result of discrete wavelet transform. Thus, most quantization methods of wavelet or sub band image compression algorithms can be followed in our scheme directly to yield good compression performance. In the quantization phase, we design a multilevel threshold scheme to further enhance the result of SPIHT by taking the significance of the pixel values and the hierarchical levels into account. Furthermore, the proposed scheme can be realized only by few integer additions and bit shifts. Simulation results indicate that the visual quality of the designed efficient spatial prediction-based image compression scheme is competitive with JPEG. All the above features make the designed image compression scheme beneficial to the applications of real-time and wireless transmission in low computational power environments. Lossless image compressions in spatial domain using Run Length Encoding (RLE) mechanism in place of simple arithmetic operation upon a certain bit-stream improve the compression ratio[20]. Huffman coding suffers from the fact that the uncompressed need have some knowledge of the probabilities of the symbols in the compressed files this can need more bit to encode the file if this information is unavailable compressing the file requires two passes, first pass: find the frequency of each symbol and construct the Huffman tree second pass: compress the file[31].

2.1 Related Work:

Spatial domain techniques involve the methods for reducing the number of bits required to represent the information contained in the image by directly operating on the raw image. Such methods usually include two stages[23]. The first stage involves the use of techniques such as image segmentation, sub sampling and interpolation, etc. This is followed by a second stage involving efficiently encoding the result from the first stage. Generally, spatial smoothness of images is common; it means to expect a given pixel to be much like the one in its neighbour. If the given pixel value confirms to expectation of being close to the previous value, then little information is already gained by the event of learning the current pixel's value. Consequently, only a little information needs to be recorded, so that the decoding process can reconstruct the pixel value. Algorithm used in lossless image data compression in spatial domain[23,20] for gray scale images is used here and proposed the same algorithm (with some modification) for color images.

Now question arises that how spatial domain algorithm[23,20] for gray scale image can be used for color image with other compression technique to achieve this goal. To achieve this goal we proposed a new algorithm which integrates existing algorithm[23,20] with LZW algorithm for color image. Complete algorithm is defined as follows.

2.2 Proposed Work:

The proposed work will begin with understanding present work on lossless image compression in spatial domain [23,21,20] and then improving the spatial domain compression algorithm by integrating with LZW encoding algorithm. The proposed algorithm is only for RGB colored image or for gray scale image [10,14,17].

- *Encoding Procedure*

1) Read a raw image as an input.
2) If the type of input image is RGB or gray scale image then proceed to next step otherwise exit from the algorithm.
3) Separate RGB color planes otherwise continue for a single planes of a gray scale image.
4) Scan each plane by taking non-overlapped block of dimension m x n.
5) Find out the minimum pixel value in selected block.
6) Find the Minimum value in selected m x n block.
7) Subtract this minimum value from each pixel value of that block every pixel in separate new m x n block called i-th block.
8) Add 11 bits header with this block of resultant values (first three bits are used to represent number of bits used to represent each pixel data and 8 bits for Min value of block).
9) Read each block along with their associated header in snake like order.
10) Generate the bit sequence from the values of each block and associated header in some pre-specified fixed order.
11) If number of rows and columns are not exact multiple of size of block (m x n) then code remaining column and row pixel value in 8 bits binary sequence and append it at the end of binary sequence generated in step10.

12) Supply sequence of binary digits to LZW algorithm.
13) Collect compressed data as an output.

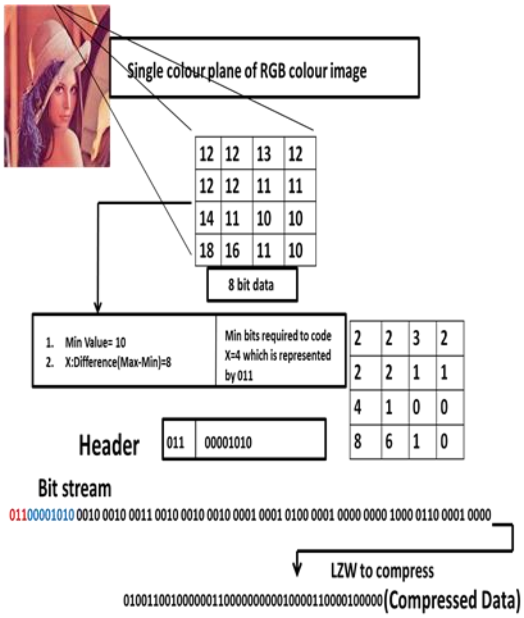

Fig. 1: Encoding Procedure

- Decoding Procedure:

1) Collect compressed data as an input.
2) Supply compressed data to LZW algorithm to decompress it.
3) Find the header (First eleven bits) in bit sequence obtained in step2.
4) Find the minimum value by parsing the header.
5) Find the number of bits by which each pixel value is denoted in each block by parsing the header3.
6) Generate, each pixel value X of a block in predefined order by selecting number of bits from bit stream.
7) Add minimum value to each pixel value X and generate original value(Y) of each block. Repeat this step for all pixels in a block.
8) Code the remaining bit stream in decimal by taking 8 bit at a time and append in row and column accordingly.
9) Repeat the above steps for whole image (each color plane) and regenerate the original image.

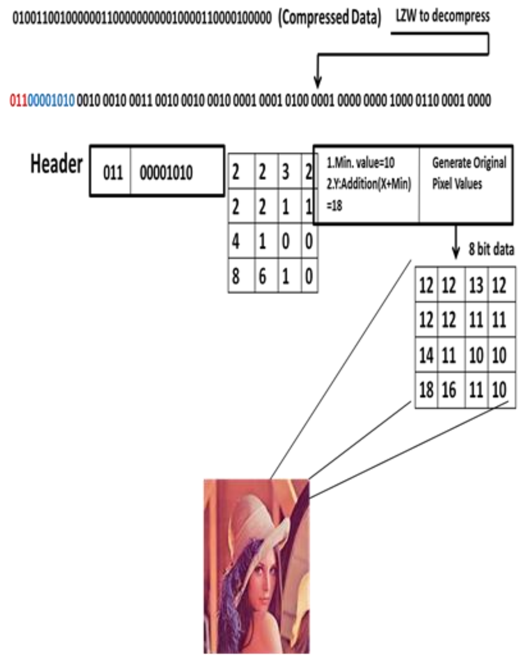

Fig. 2: Decoding Procedure

III. RESULT & DISCUSSION

This section provides details of the result obtained by executing proposed algorithm with different test image as taken in table. Compression size of test images are compared with different image formats and with proposed algorithm and plotted in fig. All codes for compression and decompression are coded in MAT LAB.

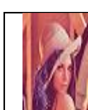					
(T1)	(T2)	(T3)	(T4)	(T5)	(T6)

Table 1: Test images

In the above table we have presented all the taken test images. All test images are named as T1, T2, T3, T4, T5 and T6 respectively.

Test images	PNG (Reduced size of original test images)	JPEG	BMP	GIF	TIF	Proposed Method(4x4)	Proposed Method(8x8)
T1	7.83	3.35	7.97	2.57	4.11	2.99	1.30
T2	7.92	2.93	7.97	2.66	3.87	2.96	1.30
T3	10.8	3.71	10.7	3.04	5.00	4.07	1.36
T4	11.3	3.70	11.8	3.30	5.30	4.35	1.81
T5	7.87	3.45	7.97	2.75	4.09	2.97	1.30
T6	12.4	4.92	11.8	3.89	5.72	4.52	1.83

Table 2: Compression Result

In the above table compression size of test images are compared with different image formats and with proposed algorithms.

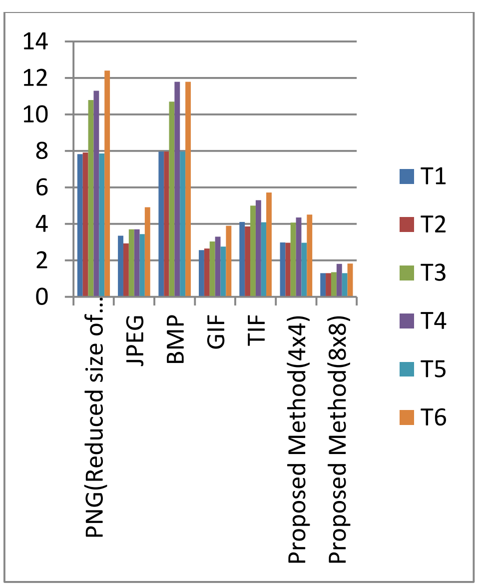

Fig. 3: Bar chart of compression result

Above figure shows and compared the size of test images with proposed algorithm. The test images are in the format of JPEG, TIF, BMP, GIF and PNG. Proposed algorithm provide much better compression than TIF, BMP, GIF and PNG but approximately same to JPEG. Dimension of the images are kept constant during all image format.

Compression Ratio:
Compression Ratio = Original Image Size / Compressed Image Size.

Test images	PNG(Reduced size of original test images)	JPEG	BMP	GIF	TIF	Proposed Method(4x4)	Proposed Method(8x8)
T1	7.83	2.33	0.98	3.04	1.90	2.61	6.02
T2	7.92	2.70	0.99	2.97	2.04	2.67	6.09
T3	10.8	2.91	1.00	3.55	2.16	2.65	7.94
T4	11.3	3.05	0.95	3.42	2.13	2.59	6.24
T5	7.87	2.28	0.98	2.86	1.92	2.64	6.05
T6	12.4	2.52	1.05	3.18	2.16	2.74	6.77

Table 3: Compression Ratio

In this above table the compression ratio is being calculated. The proposed algorithm provide high compression ratio than TIF, BMP, GIF and but not better than JPEG (say near to JPEG).

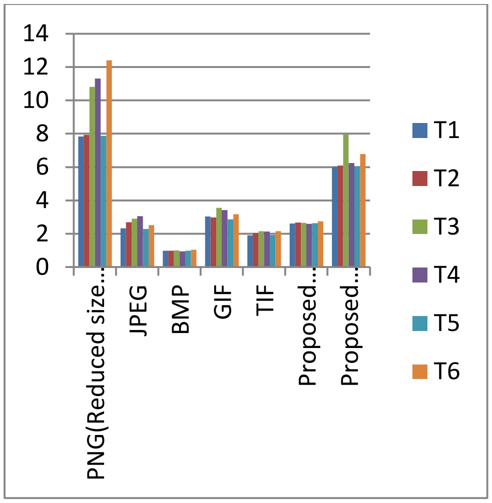

Fig. 4: Bar chart of compression ratio

The above bar chart shows that the proposed algorithm provide high compression ratio rather than TIF, BMP, GIF and but not better than JPEG (say near to JPEG).

IV. CONCLUSION

In this work, an integrated approach to spatial domain lossless image compression method is used which provides better compression ratio than existing algorithm except JPEG. The algorithm is basically designed with concern to minimize communication overhead and storage purpose which require less data to communicate or store but generate original image at receiver end. The algorithm is properly analysed and compared with another existing lossless algorithms. The proposed algorithm achieve better compression ratio than existing algorithms except JPEG.

According to table 4.3 compression ratio of proposed algorithm is much better than existing algorithm. We have not calculated MSE and PSNR because our algorithm is integrated with LZW to overcome communication overhead.

As a future scope, we can calculate MSE and PSNR at first phase of proposed algorithm. It is suggested to reduce the number of arithmetic operation required in encoding and decoding process of proposed algorithm so that it can be used as an efficient algorithm in place of any other algorithm. In this work we have taken 4x4 and 8x8 fixed size block. Another size of block can also be taken to achieve better compression ratio.

REFERENCES

[1] Amel Bey Boumezrag "*An Improved Algorithm for Image Compression Based on Biorthogonal Wavelet, DCT and Competitive Neuronal Networks*", International Journal of Computer Theory and Engineering, DOI: 10.7763/IJCTE.2017.V9.1117, Vol. 9, No. 2ISSN: 1793-8201 , April 2017.

[2] Sahib Khan, Muhammad Abeer Irfan, Muhammad Ismail, Tawab Khan, Nasir Ahmad "*Dual lossless compression based image steganography for low data rate channels",* IEEE, ISBN: 978-1-5090-5985-0, 12 October 2017.

[3] Juanita blue, Joan Condell, Tom lunnay "*Identity Document Authentication using Steganographic Techniques: The Challenges of Noise*", IEEE, ISBN: 978-1-5386-2221-6, 20 July 2017.

[4] Vandana rajput, Sandeep kumar tiwari, Rohit gupta "An Enhanced Image Security Using Improved RSA Cryptography and Spatial Orientation Tree Compression Method", IEEE, ISBN: 978-1-5090-4621-8, 26 June 2017.

[5] Hao Wu, Xiaoyan Sun, Senior Member, IEEE, Jingyu Yang, Wen jun Zeng, Fellow, IEEE and Feng Wu, Fellow, IEEE "*Lossless Compression of JPEG Coded Photo Collections*", IEEE, ISSN: 1941-0042, 06 April 2016.

[6] Yun-Qing Shi, Xiaolong Li, Xinpeng Zhang, Hao-Tian Wu, and Bin Ma "*Reversible Data Hiding: Advances in the Past Two Decades*", IEEE, ISSN: 2169-3536, 26 May 2016.

[7] Ali A. Al-hamid, Ahmed Yahya and Reda A. El-Khoribi "*Optimized Image Compression Techniques for the Embedded Processors*", International Journal of Hybrid Information Technology, ISSN: 1738-9968, 2016.

[8] Achinta Roy, Dr. Lakshmi Prasad Saikia "*a comparative study on lossy image compression techniques*", International Journal of Current Trends in Engineering & Research (IJCTER), e-ISSN: 2455–1392, June 2016.

[9] Jitendra Meghwal, Akash Mittal, Yogendra Kumar Jain "*Efficient Image Compression Technique using Clustering and Random Permutation*", Int. Journal of Engineering Research and Applications, ISSN: 2248-9622, January 2016.

[10] K.Vidhya, G. Karthikeyan, P. Divakar, S. Ezhumalai "*A Review of lossless and lossy image compression techniques",* International Research

Journal of Engineering and Technology (IRJET), ISSN: 2395-0072, 04-Apr-2016.

[11] Akhand Pratap Singh, Dr. Anjali Potnis, Abhineet Kumar "*A REVIEW ON LATEST TECHNIQUES OF IMAGE COMPRESSION*", International Research Journal of Engineering and Technology (IRJET), ISSN: 2395-0072, 07-July-2016.

[12] Manjit Sandhu, Jaipreet Kaur, Sukhdeep Kaur "*Matlab Based Image Compression Using Various Algorithms*", International Journal of Advanced Research in Computer Science and Software Engineering, ISSN: 2277 128X, April 2016.

[13] Pranjal Shrivastava, Sandeep Pratap Singh "*A Survey on Image Steganography Techniques using Compression*", International Journal of Advanced Research in Computer and Communication Engineering, ISSN: 2319 5940, February 2016.

[14] Zhe Wang, Sven Simon, Yousef Baroud, Seyyed Mahdi Najmabadi "*Visually Lossless Image Compression Extension for JPEG based on Just-noticeable DistortionEvaluation*", IEEE, ISSN: 2157-8702,02 November 2015.

[15] Xianming Liu, Xiaolin Wu, Jiantao Zhou, Debin Zhao "*Data-driven Sparsity-based Restoration of JPEG-Compressed Images in Dual Transform-Pixel Domain*", IEEE, ISSN: 1063-6919, 15 October 2015.

[16] Haider Al-Mahmood, Zainab Al-Rubaye "*Lossless Image Compression based on Predictive Coding and Bit Plane Slicing*", International Journal of Computer Applications, ISSN: 0975 – 8887, May 2014.

[17] Archana Parkhe, ilam Bire, Anuja Ghodekar, Tejal Raut, Tanuja Sali "*Enhancing the Image Compression Rate Using Steganography* ", The International Journal Of Engineering And Science (IJES), ISSN: 2319 – 1805, 2014.

[18] Hao Wu, Xiaoyan Sun, Jingyu Yang, Feng Wu "*Lossless Compression of JPEG Coded Photo Albums*", IEEE, ISBN: 978-1-4799-6140-5, 2014.

[19] A. Alarabeyyat, S. Al-Hashemi, T. Khdour, M. HjoujBtoush, S. Bani-Ahmad, R. Al-Hashemi "*Lossless Image Compression Technique Using Combination Methods*", Journal of Software Engineering and Applications, ISSN: 752-763, June 22nd, 2012.

[20] Mahmud Hasan, Kamruddin Md. Nur "*An Improved Approach for Spatial Domain Lossless Image Data Compression Method by Reducing Overhead Bits*", International Journal of Scientific & Engineering Research, ISSN 2229-5518, April-2012.

[21] Ms. G.S. Sravanthi, Mrs. B. Sunitha Devi, S.M. Riyazoddin & M.Janga Reddy "*A Spatial Domain Image Steganography Technique Based on Plane Bit Substitution Method*", Global Journal of Computer Science and Technology Graphics & Vision, ISSN: 0975-4350, Year 2012.

[22] CHENG-CHEN LIN AND YIN-TSUNG HWANG "*Lossless Compression of Hyperspectral Images Using Adaptive Prediction and Backward Search Schemes*", JOURNAL OF INFORMATION SCIENCE AND ENGINEERING 27, ISSN: 419-435, 2011.

[23] Syed Ali Hassan, Mehndi Hussain "*Spatial Domain Lossless Image Data Compression Method*", International Conference on Information and Communication Technologies (ICICT), ISIN: 978-1-4577-1553-2, 23-24 July 2011.

[24] Sachin Dhawan "*A Review of Image Compression and Comparison of its Algorithms*", IJECT, ISSN: 2230-9543, March 2011.

[25] Cheng-Chen Lin and Yin-Tsung Hwang "*An Efficient Lossless Compression Scheme for Hyperspectral Images Using Two-Stage Prediction*", IEEE, ISSN: 1558-0571, 08 March 2010.

[26] Malay Kumar Kundu, Sudeb Das "*Lossless ROI Medical Image Watermarking Technique with Enhanced Security and High Payload Embedding*", IEEE, 2010.

[27] Abbas Cheddad, Joan Condell, Kevin Curran, Paul Mc Kevitt "*A hash-based image encryption algorithm*", Elsevier, ISSN: 879–893, 28 October 2009.

[28] Pabbisetti Sathyanarayana, and Hamid R. Saeedipour "*Digital Image Compression and Decompression Using Three Different Transforms and Comparison of Their Performance", Proceedings of International Conference on Man-Machine Systems, September* 15-16 2006.

[29] Mehmet UtkuCelika, Gaurav Sharma, A. Murat Tekalp "*Gray-level-embedded lossless image compression*", Signal Processing: Image Communication 18, ISSN: 443–454, 28 January 2003.

[30] Ricardo L. de Queiroz "*Processing JPEG-Compressed Images and Documents*", IEEE, ISSN: 1057–7149, DECEMBER 1998.

[31] Jagdish H. Pujjar, Lohit M. Kadlaskar "*A NEW LOSSLESS METHOD OF IMAGE*

COMPRESSION AND DECOMPRESSION USING HUFFMAN CODING TECHNIQUES", Journal of Theoretical and Applied Information Technology, 2005 – 2010.

[32] C.S.Rawat, Seema G. Bhateja, Dr. Sukadev Meher "*A Similar Structure Block Prediction for Lossless Image Compression*", International Journal of Computer Science & Communication Networks, ISSN: 2249-5789.