Color Bayer CFA Image Compression using Adaptive Lifting Scheme and SPIHT with Huffman Coding

Shreykumar G. Bhavsar[1] Viraj M. Choksi[2]
[1]P.G Research Scholar [2]Project Scientist
[1,2]Department of Electronics & Communication Engineering
[1]Parul Institute of Engineering & Technology, Limda, India [2]BISAG, Gandhinagar, India

Abstract— Recent research has focused on the new proposed Bayer pattern image compression compared to other methods of structural transformation algorithm. Based on previous work, this paper proposes a new algorithm the Bayer pattern image compression by using adaptive 9/7 wavelet transform and set partitioning in hierarchical trees (SPIHT) and Huffman coding combined. Start with a color filter array (CFA) data convolution of the low pass filter followed by a down-sampling operation after the data is converted from RGB color space into separated luminance and chrominance components of the YCbCr color space. The lastly achieved more data compressed by using new proposed algorithm method for compression.

Key words: Lifting scheme based wavelet transform, Color Filter Array (CFA), Color space conversion, Compression Ratio (CR), Peak signal to Noise Ratio (PSNR)
General Terms: Compression, Color Bayer CFA image

I. INTRODUCTION

Color Filter Array (CFA) is an array of alternating color filters has samples of one color band at each pixel position. The general CFA pattern in the Bayer pattern[1],as in Fig.1, which has features red and blue filters at alternate pixel position in both directions and green filters arranged in quincunx pattern at the remaining tissue location. By using this pattern get results is half of image resolution due to green band. In human visual system have peak sensitivity in middle wavelength so that additionally green sampled in this system.

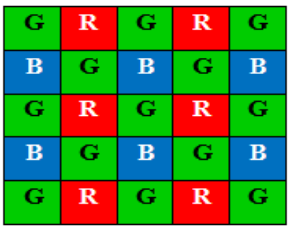


Fig. 1: Arrangement of Bayer Pattern CFA

Traditional Bayer pattern image compression is shown as Fig.2 (a), wherein the color filter array (CFA) data is first interpolated to achieve a full color image. When the full-color image is then compressed in the process, the amount of data is too large to be stored or compressed. To solve this problem, some previous work made, CFA is first compressed data so that the memory or transmitted previously inserted, as shown in Fig.2(b), which can reduce the storage and transmission bandwidth, to reduce the pressure and the compression of the relatively low complexity.

Maintaining only one color in each pixel of the Bayer pattern image, each pixel value of the adjacent space is not continuous, which will cause a full-color image than the high frequency component before sampling in the larger[15]. High-frequency components are compressed to a bad image of high magnification, if Bayer image data is directly compressed. Accordingly, emergence of various algorithms which transform Bayer image data before compression has been used.

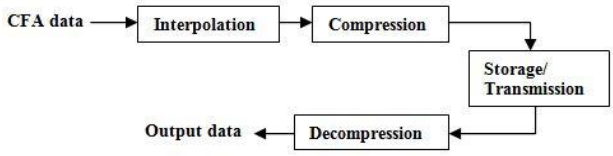


Fig. 2(a): Arrangement of Interpolation before compression

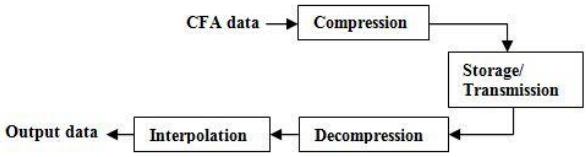


Fig. 2(b): Arrangement of Compression before interpolation

Lee [6] proposed a Bayer image data is first converted from RGB color space to YCbCr color space, wherein the Cb and Cr components are equal to 4:2:0 sampling operation, while the Y component needs to be converted into a diamond having a 45^0 rotation. Then the data can be made of a shape adaptive discrete cosine transform process transform, it cannot be applied directly to the existing compression algorithms such as JPEG and JPEG2000.

Xie [1] [10], revised to a new and efficient method for Bayer image compression based on wavelet transform upgrade scheme and SPIHT algorithm. Conversion proposed algorithm from the simulation, it can be discussed in the output performance of the algorithm better than improve the structure conversion algorithm and better visual quality has been achieved PSNR.

Koh [12], the challenge facing structural transformation has been revised to be an effective method of Bayer pattern image and to improve the compression quality. On this basis, the structure of an improved conversion algorithm discussed solutions to further improve the compression effect. Improve the structure using a combination of multi-level wavelet transform and convert lifting scheme algorithm to improve the program and set partitioning in hierarchical trees(SPIHT) algorithm and also effective way to get a digital camera with a color filter array (CFA).

Li Ming-Ming [2] discussed the set partitioning in hierarchical trees (SPIHT) coding algorithm for the original compression core for better performance from exists lossy image compression function Bayer. After completion of the encoding process of the image, leading to the conclusion that a significant cause SPIHT compression encoding scheme to improve performance, and concluded that low artifacts compared to similar processing equipped with a JPEG encoder.

II. WAVELET TRANSFORM 9/7 LIFTING

Sweldens [11] achieved by improving the structure of the discrete wavelet transform is proposed a new method. Relative to conventional convolution filtering method and a lifting structure with fewer advantages of low complexity calculation step, which have the calculation of the lifting structure filter efficiency higher than convolution filter [11]. daubechies wavelet proposed polyphase matrix of 9/7 wavelet filter is broken down to produce a series of triangular matrices, and gives the steps to enhance the 9/7 wavelet filter.

Images have come before lifting wavelet expansion in an appropriate manner and transformed SPIHT coding applications. Lifting solutions to effectively solve some problems, the wavelet transform traditional mode of existence by reducing the memory required for its implementation. The simple version of the lifting 9/7 wavelet transform scheme has described in Fig. 3. The follow consists of three steps: Split, Predict and Update. Split input data is divided into even smaller sample of *Xe* and odd samples *Xo*. The purpose is to predict the relevance of the data, we can act independent data structures using predictive operation P, even if the signal and obtain the prediction value of the odd signal. Update it introduces the operator U update and maintains the integrity of the signals *Xe* and *Xo*.

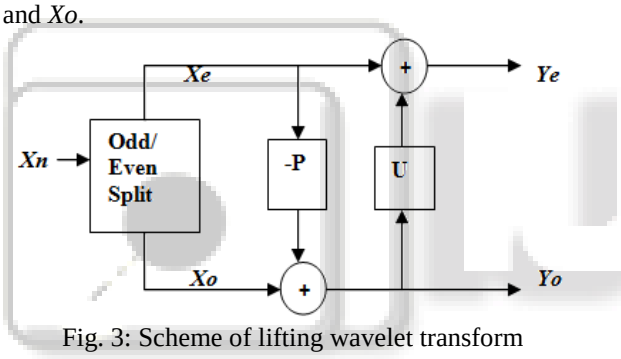


Fig. 3: Scheme of lifting wavelet transform

III. SET PARTITIONING IN HIERARCHICAL TREES (SPIHT)

In general, SPIHT image compression algorithm based on wavelet transforms. It provides the highest image quality, accurate and error protection coding bit rate [5] . SPIHT has to use of three lists - a List of Significant Pixels (LSP), a List of Insignificant Pixels (LIP) and a List of Insignificant Sets (LIS).

Based on following concepts of SPIHT algorithm:

- Transmission Process of ordered bit plane progressive
- Process of Set partitioning sorting algorithm.
- Process of Spatial orientation trees.

These coefficients location lists have contains their coordinates. After initialization, each level of the algorithm requires a two stage threshold values - sorting pass (are organized in the list), and refinement pass (which performs the actual transfer of the progressive coding). The result is a form of bit stream [3]. It can convert all of the bits coded by the image is completely restored. However, the wavelet transform output only when it is infinite number of reconstructed completely inaccurate digital storage.

SPIHT coding starts running two passes: ordering process pass and refinement process pass. One main characteristic is that the sequence is not explicitly transmitted. The first pass is sorting through. It first moves LSP and LIP browse all significant factors, and the output of its symbols. Then browse LIS implementation of effective information and follow the partition sorting algorithms.

The second process pass is refining pass. It browse the coefficient of LSP, and outputs a single bit alone basis, the current threshold. After completion of the two times, the threshold value is divided by 2, and twice again performed in the encoder [7]. This process is applied recursively, until the output reaches the required number of bits.

A. Algorithm:

1) Step of Initialization:

Output n=|log2(max(i,j){c(i,j)}|; has a set the LSP as empty list and other add the coordinates (i,j) € H to the LIP and only that with descendants also to the LIS.

- LIP: all tree roots of co-ordinates – scale of co-ordinates in coarsest subband
- LIS: all tree roots of co-ordinates with nonempty descendent trees – scale of co-ordinates in coarsest subband pointing to descendant trees
- LSP: empty

2) Step of Sorting Pass:

The basis of the most significant bit-plane is transmitted on sorting information

3) Step of Refinement Pass:

For every entry of (i,j) in LSP part, except those included in the last sorting pass, and the output n^{th} most significant bit of $|c_{i,j}|$. Bits in bit-planes lower than the most significant bit plane is transmitted.

4) Step of Quantization - Step Update:

Decrement n by 1 value and go to the Step-2

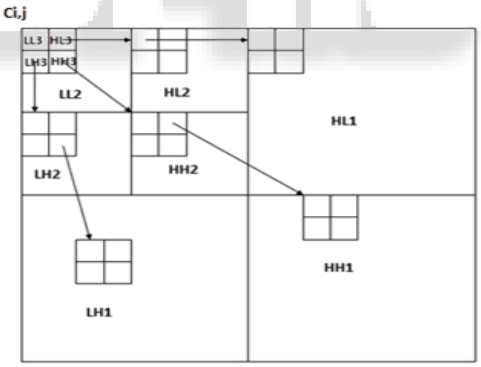


Fig. 4: Structure of SPIHT coding

SPIHT algorithm is realized in positioning the tree split by multiple spaces. If the set is very significant so it can be divided into several sub-sets to test their significance. Partition continues to repeat until all the important factor is only one set of coefficients.

IV. HUFFMAN CODING

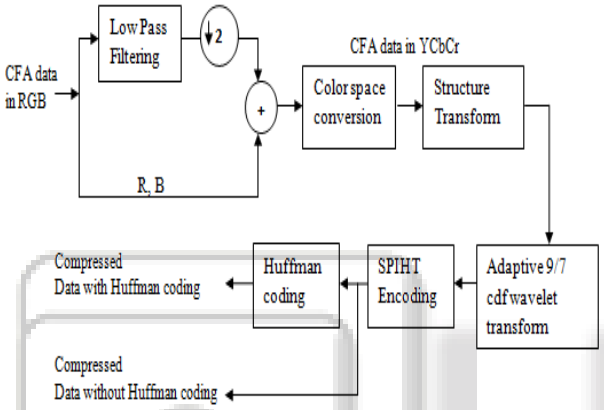
Huffman coding can an entropy encoding algorithm has mainly used for lossless data compression. The term refers to the estimated probability of each possible value of an encoding source symbols using a variable length code table, wherein, in the variable length code table has occurred on a particular manner based on the source symbol is derived [16]. It is used for selecting each symbol means, thereby generating the specific method used for the expression of shorter than the bit string for the source symbol is not

common in most of the common prefix of the source symbols.

This algorithm is based on statistical Huffman coding as which means that the probability of a symbol which has a direct impact representative length. There are more likely to be a sign that their position will be the size. In any document, some characters are used more than others. Binary notation to indicate the desired number of bits per character depends on represent that character. It can using one bit to represent two characters, i.e., '0' represents first character and '1' represents second character. It can use two bits to represent four characters. And so on [4].

V. PROPOSED SCHEME OF STRUCTURE OF COLOR IMAGE COMPRESSION

This Paper have used new proposed algorithm process are shown in below Fig. 5.



. Fig. 5: Proposed Scheme of structure of image compression algorithm flow

Those steps of color space conversion and structure conversion are same as those of the improved structure conversion method for original Bayer image, and the second part of the algorithm is based on adaptive 9/7 lifting wavelet transform and SPIHT instead of the JPEG compression in the original "Structure Conversion" algorithm.

First, the conversion of the structure is applied to the G component and the data in the RGB color space is converted into YCbCr color space, because the pixels in the RGB the correlation between the color space YCbCr color space than the higher. Since original rectangular distribute of R and B components and the loose rectangle only needs to become tight rectangle without lowpass filter and structure conversion.

A. Color Space Conversion:

Bayer raw images can be viewed with a size of 2x2 blocks of GB/RG. By using R, G and B components have be converted into the transformation matrix for luminance and chrominance values of color space in the YCbCr components [10], as shown in below Fig. 6. Cb and Cr components are equal to 4:2:0 sampling and color space conversion has been expressed as below:

$$\begin{bmatrix} Y1 \\ Y2 \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 128.6 & 0 & 25 & 65.5 \\ 0 & 128.6 & 25 & 65.5 \\ -37.1 & -37.1 & 112 & -37.8 \\ -46.9 & -46.9 & -18.2 & 112 \end{bmatrix} \begin{bmatrix} G1 \\ G2 \\ B \\ R \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 128 \\ 128 \end{bmatrix}$$

Where, 1 has represents upper left corner, while 2 has represents lower right corner.

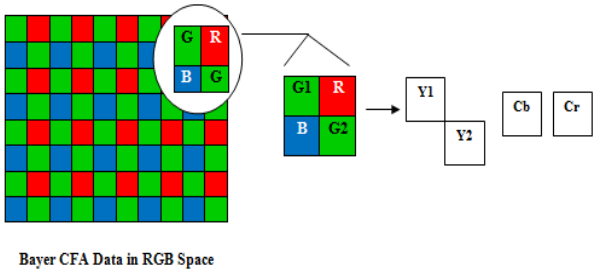


Fig. 6: Diagram of color space conversion

B. Low-pass Filter:

Since the G component is plum, it needs to become a rectangle. Appears directly in the odd and even columns will generate a pseudo-high frequency component to suppress the generation of the pseudo high-frequency component [2], the G component of the smoothing processing needs, which can be divided into two steps: the lowpass filtering and sampling the column 2:1. Impulse response function of the lowpass filter is as given below:

$$h_l = \frac{1}{4}\begin{bmatrix} 0 & 0 & 1 \\ 0 & 2 & 4 \\ 0 & 0 & 1 \end{bmatrix}$$

After the sampling of columns, G component as a rectangle, this is equal to the number of rows and number of columns of the original image into half of the original number of columns. After converting the image data structure and color space conversion achieved by the 9/7 wavelet compression algorithm and SPIHT. After storing or transmitting the compressed image data is decompressed to restore the CFA.

VI. PERFORMANCE EVALUATION AND EXPERIMENTAL RESULTS

To test the performance of the algorithm, the selected Lena image size 512×512 for test and in the full-color image 24 bits/pixel Bayer CFA algorithm requires data to be obtained by the following samples.

Bit Rate (bpp)	CR without Huffman Code	CR with Huffman Code
0.2	40.0128	80.0199
0.3	26.6733	53.344
0.4	20.0043	40.0072
0.5	16.0037	32.0066
0.6	13.3353	26.6699
0.7	11.4303	22.8599
0.8	10.0014	20.0024
0.9	8.8901	17.7799
1	8.0012	16.0022

Table 1: Compression ratio with Huffman and without Huffman code (Lena)

Bit Rate (bpp)	Baboon Image		Pepper Image	
	CR without Huffman Code	CR with Huffman Code	CR without Huffman Code	CR with Huffman Code

0.3	21.3409	42.6792	32.5229	65.0402
0.4	16.0051	32.0086	24.3908	48.7784
0.5	12.8027	25.6044	19.5096	39.0172
0.6	10.6689	21.3371	16.258	32.5145
0.7	9.1447	18.289	13.9354	27.8697
0.8	8.0016	16.0029	12.1935	24.3861
0.9	7.1122	14.2241	10.8379	21.6751
1	6.401	12.8018	9.7542	19.5078

Table 2: Compression ratio with Huffman and without Huffman code (Baboon and Pepper)

Bit Rate (bpp)	JPEG [1] (PSNR)	JPEG2000 [9] (PSNR)	SPIHT [1] (PSNR)	CR without huffman Code Using SPIHT	CR with huffman Code Using SPIHT
0.2	28.43	30.75	31.19	40.0128	80.0199
0.3	30.69	31.56	32.73	26.6733	53.344
0.4	31.93	33.35	33.93	20.0043	40.0072
0.5	32.91	33.95	34.86	16.0037	32.0066
0.6	33.65	34.67	35.72	13.3353	26.6699
0.7	34.29	36.23	36.57	11.4303	22.8599
0.8	34.78	36.05	37.27	10.0014	20.0024
1	35.77	37.93	38.55	8.0012	16.0022

Table 3: Comparison of different methods based on PSNR value and Compression ratio with Huffman and without Huffman code (Lena)

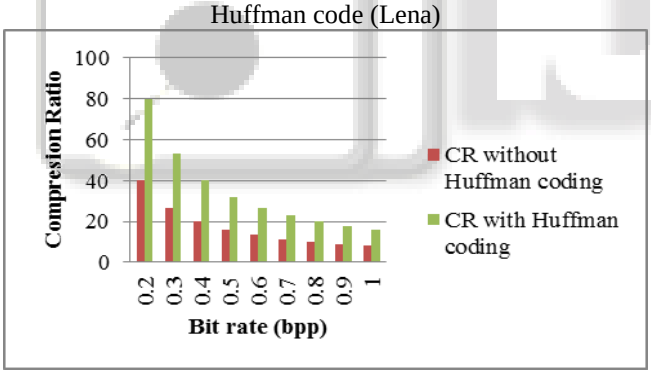


Fig. 7(a): Chart of Compression Ratio vs Bit Rate(bpp) (Lena)

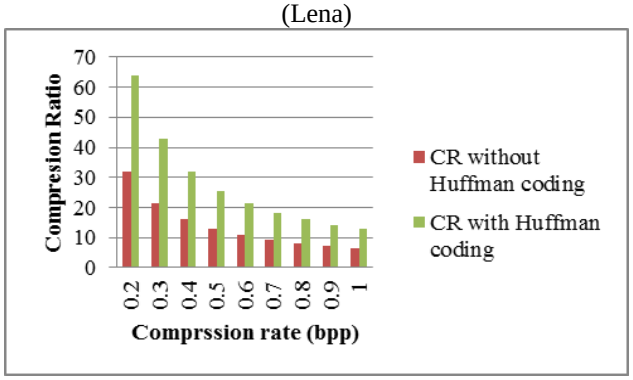


Fig. 7(b): Chart of Compression Ratio vs Bit Rate(bpp) (Baboon)

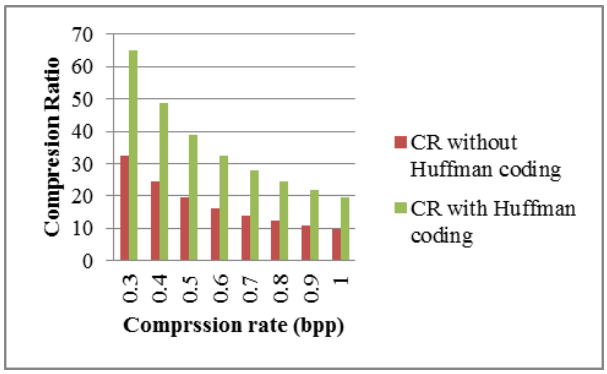


Fig. 7(c): Chart of Compression Ratio vs Bit Rate (bpp) (Pepper)

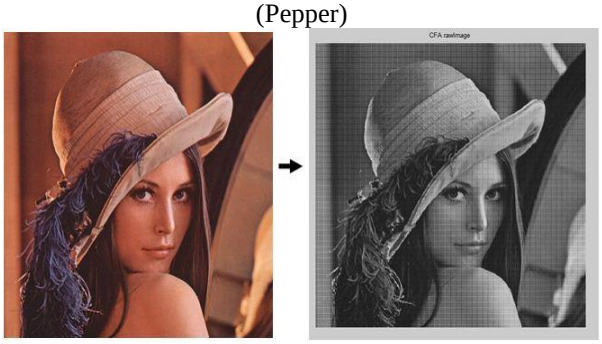


Fig. 8(a): True color image to CFA image (Lena)

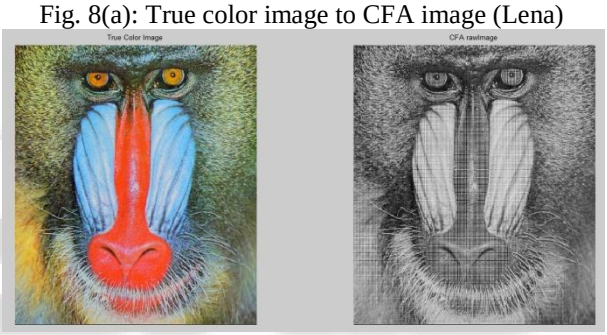


Fig. 8(b): True color image to CFA image (Baboon)

Fig. 8(c): True color image to CFA image (Pepper)

VII. CONCLUSION

This paper focuses on lifting scheme is proposed on the basis of the Bayer pattern image improved structural transformation and adaptive 9/7 wavelet transform followed by Huffman coding and improved SPIHT compression algorithm. The simulation results of the test images show that the output of the algorithm to improve the structure conversion algorithm formed Compression Ratio and better data compression has been achieved. Thus, we can conclude that this algorithm is more suitable for the Bayer CFA pattern image compression.

VIII. ACKNOWLEDGMENTS

For the successful completion of this article, we thank all scholars, guides, family members and dear friends who directly or indirectly contribute to making our job done.
The Authors wish to thank T.P.Singh, Director, BISAG for constant encouragement to our research work.

REFERENCES

[1] Xie Song-Zhao , Wang Cheng You, Zhi Qiang, "Image Compression Using Wavelet Transform With Lifting Scheme And Spiht In Digital Cameras For Bayer CFA", International Conference on Wavelet Analysis and Pattern Recognition, Tianjin, 14-17 July, IEEE 2013.
[2] Ming-Ming Li, Zhan-Jie Song, Ai-Ping Yang, Zheng-Xin Hou and Zhe Huang, "Lossy Compression of Bayer Image with SPIHT", IEEE 2011.
[3] Saraf Puja, Sisodia Deepti, Sinhal Amit and Sahu Shiv, "Design and Implementation of Novel SPIHT Algorithms Image Compression", International Conference on Parallels, Distributed & Grid Computing, IEEE 2012.
[4] Srikanth Sure., Meher Sukadev, "Compression Efficiency for Combining Different Embedded Image Compression Techniques with Huffman Encoding", International conference on Communication and Signal Processing, April 3-5, IEEE 2013.
[5] Dubey Vidhi, Dubey Rahul, "A new Set Partitioning in Hierarchical (SPIHT) Algorithm and Analysis with Wavelet Filters", International Journal of Innovative Technology and Exploring Engineering (IJITEE), August 2013.
[6] Lee S.Y., Ortega A., "A novel approach of image compression in digital camera with a Bayer color filter array", Vol.3, IEEE 2001.
[7] Chourasiya Ritu and Prof. Shrivastava Ajit ,"A Study Of Image Compression Based Transmission Algorithm Using Spiht For Low Bit Rate Application", Advanced Computing: An International Journal ,Vol.3, No.6, November 2012.
[8] Singh Reena, Srivastava V. K., "JPEG2000: A Review and its Performance Comparison with JPEG", International Conference on Power, Control and Embedded Systems, 2012.
[9] Boukli hacene I., Beladghem M., "Lossy Compression Color Medical Image Using CDF Wavelet Lifting Scheme", I.J. Image, Graphics and Signal Processing, 11, 53-60, 2013.
[10] Xie X., Li G. L., and Wang Z. H., "A low complexity and high efficient method for image compression with Bayer CFAs", Tsinghua Sci. and Technol., Vol. 12, No.1, pp. 22-29, Feb. 2007.
[11] Sweldens W., "The lifting scheme: A new philosophy in Biorthogonal wavelet constructions", in Processing on SPIE, vol. 2569, pp. 68–79, 1995.
[12] Koh C. C., Mukherjee J., and Mitra S. K., "New efficient method of compression in digital camera with color filter array", Vol-49, No-4, IEEE 2003
[13] Plataniotis K. N. and Venetsanopoulos A. N., "Color image processing and applications", New York, NY, Springer-Verlag New York, 2000.
[14] Mancuso M. and Battiato S., "An introduction to the digital still camera technology", Journal of System Research - Special Issue on Image Processing for Digital Still Camera, 2001.
[15] https://en.wikipedia.org/wiki/Color_filter_array
[16] https://en.wikipedia.org/wiki/Huffman_coding

