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RAFMAN: Lossy Image Compression Algorithm for Improving Image Quality Based on Hybrid Lossless Techniques

[1]Rafeeq Al-Hashemi and [2]Ayman Al-Dmour
[1]Department of Computer Science,
[2]Department of Computer Information System, Al-Hussein Bin Talal University,
P.O. Box 20, Ma'an 71111, Jordan

Abstract: Image compression is a key technology in the development of various multimedia and communication applications. In this paper, we have proposed a new algorithm of the image compression using byte compression technique. The encoding processes starts by implementing a modified decimal Run Length Encode (RLE). The RLE counts the occurrences of the pixel values of the original image and stores the occurrences in one byte with the pixels value to merge the two bytes in one byte (value, occurrences). The output from the previous step entered into another compression stage by applying Huffman's code that boosts the compression ratio of the image. To improve quality and compression ratio of the reconstructed image, an adaptive filter is implemented. The results show that the proposed algorithm provides superior performance in terms of compression ratio and exhibiting highest (PSNR) is retained for the image in additional to low Mean Square Error (MSE).

Key words: Image compression, lossy compression, Huffman code, run length encode (RLE), set partitioning in hierarchical trees (SPIHT)

INTRODUCTION

Image compression forms the backbone for several applications such as storage of images in a database, picture archiving, TV, facsimile transmission and video conferencing. Compression of images involves taking advantage of the redundancy in the data present within an image. In order to achieve useful compression various algorithms were developed in the past. A compression algorithm has a corresponding decompression algorithm that, given the compressed file, reproduces the original file. There have been many types of compression algorithms developed. These algorithms fall into two broad types, Loss less algorithms and Lossy algorithms (Koli and Ali, 2008).

A lossless algorithm reproduces the original exactly. Whereas, a lossy algorithm, as its name implies, loses some data. Data loss may be unacceptable in many applications. For example, text compression must be lossless because a very small difference can result in statements with totally different meanings. There are also many situations where loss may be either Unnoticeable or acceptable. But various applications require accurate retrieval of image, where in one such application is medical processing Jilani and Sattar (2010). The image quality is measured in terms of PSNR and MSE:

$$MSE = \frac{1}{N.M}\sum_{i=0}^{N-1}\sum_{j=0}^{M-1}\left[\left|f(i,j) - f'(i,j)\right|^2\right] \quad (1)$$

where, f (i, j) is the original image data and f ' (i, j) is the compressed image value. Another quantitative measure is the peak signal-to-noise ratio (PSNR), based on the root mean square error of the reconstructed image. The formula for PSNR is given Saffor *et al*. (2002) and Logashanmugam and Ramachandran (2008). For good quality image, PSNR value should be as high as possible and MSE value should be as low as possible. Percentage of compression indicates by how much the size of the image has been reduced from its original size and it is given by:

$$CR = \left(\frac{\text{Original file size}}{\text{Compressed file size}}\right)\times 8 \quad (2)$$

Binary Tree Predictive Coding (Robinson, 1997) and Non-Uniform Sampling and interpolation (Rosenberg, 1990), are similar techniques. They are based on encoding the value of only some of the pixels in the image and the rest of the image is predicted from those values.

Fractal compression is based on PIFS (Partitioned Iterated Function Systems). One advantage of fractal

Corresponding Author: Rafeeq Al-Hashemi, Department of Computer Science, Al-Hussein Bin Talal University, P.O. Box 20, Ma'an 71111, Jordan

methods is super resolution; decoding the image at higher resolutions leads to much better results than stretching the original image.

Image compression usually involves a lossy transformation on the data followed by a lossless compression of the transformed data. Entropy encoding such as Huffman or arithmetic encoding (Barnsley and Hurd, 1993) is usually used.

Nearly-lossless (NL) compression, as presented by Chen and Ramabadran (1994) and Ligang and Marcellin (1995), allows compression of an image assuming that every pixel value can be changed by some small value (e). Small values of e can substantially improve the image compression ratio without any visible changes in the image (Cosman *et al.*, 1994).

Run-Length Encoding (RLE) (Kim *et al.*, 2005) is a lossless data compression technique that is well-suited to condense graphic images. In RLE, a sequence of data that represents an image is stored as a single data value and count, rather than as the original sequences. The technique utilizes the fact that same data value occurs in many consecutive data elements. However, it is not useful with files that don't have many sequences as it could potentially double the file size. Grayscale image is a black-and-white image in which the value of each pixel carries only intensity information. Such an image is composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest.

Huffman is well known that the Huffman's algorithm is generating minimum redundancy codes compared to other algorithms The Huffman coding has effectively used in text, image, video compression and conferencing system such as, JPEG, MPEG-2, MPEG-4 and H.263 etc., (Chen *et al.*, 2006). The Huffman coding technique collects unique symbols from the source image and calculates its probability value for each symbol and sorts the symbols based on its probability value. Further, from the lowest probability value symbol to the highest probability value symbol, two symbols combined at a time to form a binary tree. Moreover, allocates zero to the left node and one to the right node starting from the root of the tree. To obtain Huffman's code for a particular symbol, all zero and one collected from the root to that particular node in the same order (Lakhani, 2003; Ponalagusamy and Saravanan, 2007).

Set Partitioning In Hierarchical Trees (SPIHT) is one of the most efficient image compression algorithms. The effectiveness of the SPIHT algorithm originates from the efficient subset partitioning and the compact form of the significance information. The SPIHT algorithm defines spatial orientation trees, sets of coordinates and recursive set partitioning rules. The algorithm is composed of two passes: a sorting pass and a refinement pass. It is implemented by alternately scanning three ordered lists: List of Insignificant Sets (LIS), List of Insignificant Pixels (LIP) and List of Significant Pixels (LSP). The LIS and LIP represent the individual and sets of coordinates, respectively, for wavelet coefficients that are less than a threshold. During the sorting pass the significance of LIP and LIS are tested, followed by removal (as appropriate) to LSP and set splitting operations to maintain the insignificance property of the lists. In the refinement pass, the most significant bits in the LSP which contains the coordinates of the significant pixels, are scanned and output. The SPIHT algorithm reduces the threshold and repeats the two passes until the bit budget is met (Said and Pearlman, 1996).

As a consequence of the conflict of the huge size of raw digital images and the restricted transmission bandwidth and storage space, it is absolutely crucial to evolve compression methodologies with high compression ratio and good reconstructed quality. This study investigates existing methods for improving image quality and existing methods for improving image compression ratio. Afterward consider adapting these methods to a novel hybrid approach based on modified lossless compression techniques named decimal Run Length Encode (RLE) and Huffman's coding.

This study also proves that the improved technique works better than the existing JPEG2000 and SPHIT, a well known techniques for a lossy image compression, by considering a set of well-known images based on three metrics such as Compression Ratio (CR), Mean Squared Error (MSE) or Peak Signal-to-Noise Ratio (PSNR).

PROPOSED ALGORITHM

The proposed algorithm is illustrated in Fig. 1. In the Encode stage of the proposed algorithm (RAFMAN) the

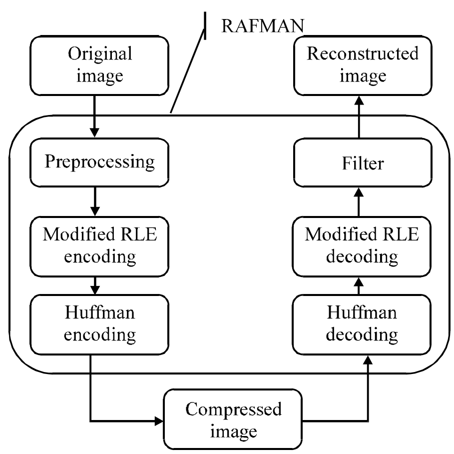

Fig. 1: Proposed algorithm encode/decode

compression starts by the preprocessing step implemented on the original image to convert the image into grayscale. In the second step, the proposed algorithm reads each block of 8 bits (Color value) and resets the Least Significant Bits (LSB) to be a place holder for the RLE runs (count).

The algorithm then implements the decimal RLE on the image blocks in order to compress the image. The reset process of the LSB that just implemented in the previous step increases the compression ratio, in other words, the reset of LSB increases the probability of similar consequent bytes (pixel color value) to be the same values which help the RLE to be more efficient to find more pixels with the same value. On another hand, the runs (pixels value occurrences) of RLE will not be stored in a separate byte, but the runs (occurrences) will store and merged with the pixel value byte in the LSB that are already empty. In case the frequency of occurrences exceeds the capability of four bits representation the algorithm will divide this pair into consecutive pairs that cope with the capability of four bits representation. The result will be a new vector comprises pairs on the form <Color value, Frequency of occurrences> as in Fig. 2.

The algorithms 1 and 2 show Encoding and Decoding of RAFMAN algorithm.

Algorithm 1: RAFMAN encoding

A. Encoding
- Input: Original Image
- Preprocessing
- Implement the Modified RLE encoding
    - Reset the LSB of the image pixel values
    - Combine the RLE results (counts) with the pixel values
- Implement Huffman's code
- Output: Compressed Image

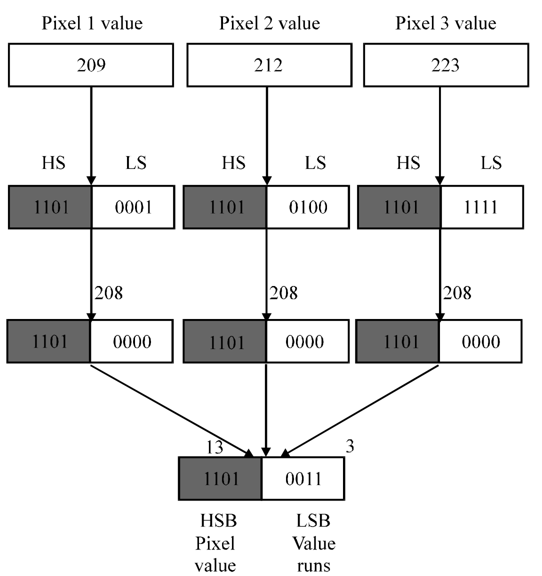

Fig. 2: The modified RLE encoding

Algorithm 2: RAFMAN decoding

B. Decoding
- Input: Compressed Image
- Implement Huffman decode
- Implement the Modified RLE Decoding
    - Separate RLE results (counts) from the pixel values
    - Implement filter to enhance to output image
- Output the Decompressed Image

The proposed algorithm increases the compression ratio by implementing Huffman's algorithm; a lossless image compression technique. With Huffman's implementation the compression ratio is boosted as illustrated in results section with no more losing in image data.

The input to the decoding stage is a vector containing the values representing a compressed image. The values are decimal representations stored in 8 bits. The bits contain two pieces of information, Color value and Frequency of runs (occurrences), originally represented using 8 bits each. Thus, the goal of the decoding process is to unfold the 8 bits back and to repeat the pixels value to its original number and then the image values will be restored by applying the RLE decode.

To unfold an 8-bit value, the 4 MSBs and the 4 LSBs must be isolated and stored in 8 bits each such that the corresponding value of each 4 bit is preserved. The result will be a new vector comprises pairs on the form <Color value, Frequency of occurrences>. Then, the RLE decoding is applied to the new vector to restore the original image. Figure 3 presents the Modified RLE decoding.

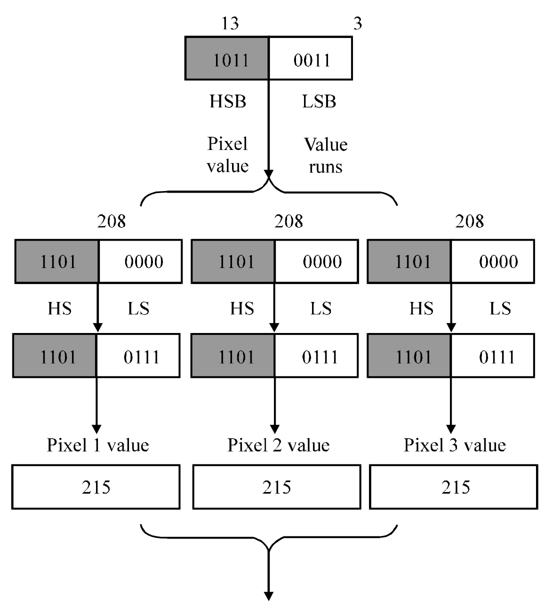

Fig. 3: Modified RLE decoding

In the decoding stage, an adaptive filter implemented to increase the quality of the compressed image. The filter is an adaptive filter based on the image while the filter analyses the compressed image and finds the best value to fill the LSB that is reset in the encode stage. This filter boost again RAFMAN algorithm results by enhancing the quality of the image and increase the PSNR and decrease the MSE in an efficient way as shown in the results section.

RESULTS AND DISCUSSION

In this study, the test images are selected from the standard gray scale images with size 512×512 (Venkateswaran and Rao, 2007). Namely: 'Lena', 'Baboon', 'Airplane' and 'Peppers' as shown in Fig. 4.

Several experimental results will be demonstrated in this section. Figure 5 illustrate the effect of the applying Huffman on the Modified RLE which accomplish improvement in compression ratio. The filter that created in the proposed algorithm improves the quality of the reconstructed mages in term of MSE, PSNR as displayed in the Fig. 6. These results are compared to the SHPIT compression algorithm as shown in Fig. 7.

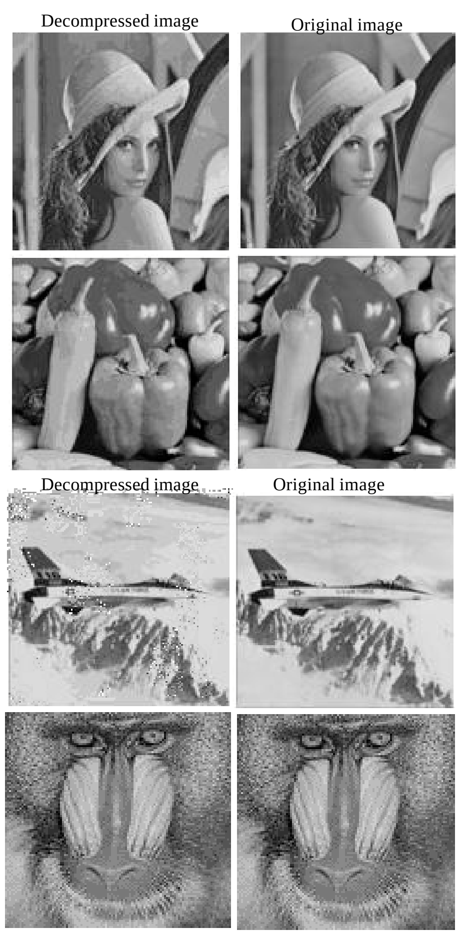

Fig. 4: Test image examples

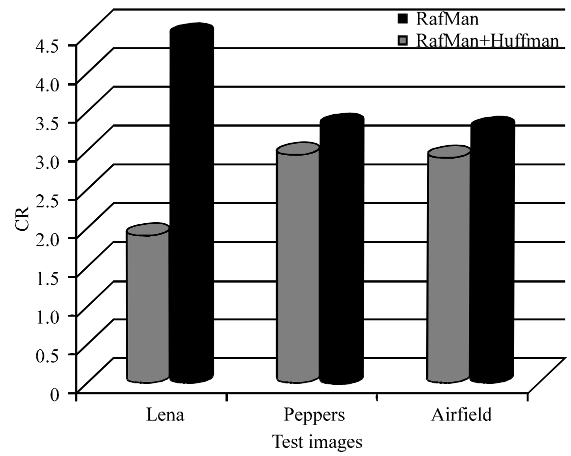

Fig. 5: The effect of using Huffman's codes

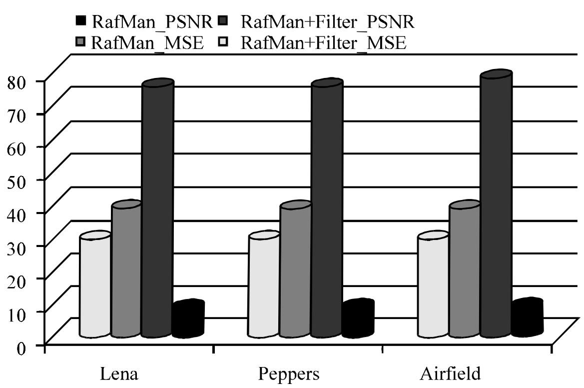

Fig. 6: The effect of the applied filter

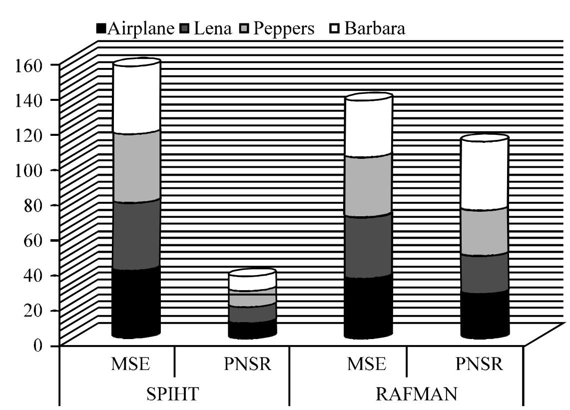

Fig. 7: RAFMAN PSNR and MSE comparison

Table 1: Bits/pixel Compression ratio for different compression methods

	Compression Ratio (Bit/Pixel)			
Image method	Proposed	CABAC	JPEG	JPEG2K
Airplane	1.87	1.53	2.08	1.68
Lena	2.29	1.85	2.69	1.99
Pepper	2.06	1.28	2.20	1.36
Baboon	2.88	2.72	3.03	2.70
Airfield	3.02	2.56	3.56	2.8

Table 1 illustrates the compression ratio using the proposed algorithm for the test images compared to (CABAC, JPEG, JPEG2K) using Eq. 2. The proposed algorithm make a tradeoff between compression ratio and image quality, thus the algorithm gives good compression ratio and qualitative images with a high PSNR and less MSE.

CONCLUSIONS

A new approach for near-lossless image compression in digital image compression based on modified RLE and Huffman has been proposed. The proposed algorithm exhibits better visual quality in terms of PSNR and MSE than the SHPIT. The results show that the compression ratio is increased for large image size.

REFERENCES

Barnsley, M.F. and L.P. Hurd, 1993. Fractal Image Compression. AK Peters Ltd., Massachusetts, USA., ISBN-10: 1-56881-000-8, pp: 244.

Chen, C.Y., Y.T. Pai and S.J. Ruan, 2006. Low power huffman coding for high performance data transmission. Int. Conf. Hybrid Inf. Technol., 1: 71-77.

Chen, K. and T.V. Ramabadran, 1994. Near-lossless compression of medical images through entropy-coded DPCM. IEEE Trans. Med. Imaging, 13: 538-548.

Cosman, P.C., H.C. Davidson, C.J. Bergin, C.W. Tseng and L.E. Moses *et al*., 1994. Thoracic CT images: Effect of lossy image compression on diagnostic accuracy. Radiology, 190: 517-524.

Jilani, S.A.K. and S.A. Sattar, 2010. Image compression approach for medical processing using modified neuro modeling. Int. J. Eng. Sci. Technol., 2: 4555-4559.

Kim, W.J., S.D. Kim and K. Kim, 2005. Fast algorithms for binary dilation and erosion using run-length encoding. ETRI J., 27: 814-817.

Koli, N.A. and M.S. Ali, 2008. A survey on fractal image compression key issues. Inform. Technol. J., 7: 1085-1095.

Lakhani, G., 2003. Modified JPEG huffman coding. IEEE Trans. Image Process., 12: 159-169.

Ligang, K. and M.W. Marcellin, 1995. Near-lossless image compression: Minimum entropy, Constrained error DPCM. Proceedings of the International Conference on Image Processing, (ICIP'95), Washington, DC., USA., pp: 298-298.

Logashanmugam, E. and R. Ramachandran, 2008. An improved algorithm for image compression using wavelets and contrast based quantization technique. Inform. Technol. J., 7: 180-184.

Ponalagusamy, R. and C. Saravanan, 2007. Analysis of medical image compression using statistical coding methods. Innovative Appl. Inform. Technol Dev. World, 2: 372-376.

Robinson, J.A., 1997. Efficient general-purpose image compression with binary tree predictive coding. IEEE Trans. Image Process., 6: 601-608.

Rosenberg, C., 1990. A lossy image compression algorithm based on non-uniform sampling and interpolation of image intensity surfaces. M.S. Thesis, Massachusetts Institute of Technology, USA.

Saffor, A., A.R.B. Ramli, K.H. Ng and D. Dowsett, 2002. Objective and subjective evaluation of compressed computed tomography CT images. Internet J. Radiol., 2: 1-5.

Said, A. and W.A. Pearlman, 1996. A new, fast and efficient image codec based on set partitioning in hierarchical trees. IEEE Trans. Circuits Syst. Video Technol., 6: 243-250.

Venkateswaran, N. and Y.V.R. Rao, 2007. K-means clustering based image compression in wavelet domain. Inform. Technol. J., 6: 148-153.