Lossless Image Compression Using Fast Arithmetic Operation

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Abstract:
In this paper we are presenting a lossless image compression coder and decoder based on fast arithmetic operations. In the proposed method, we are making use of only simple adder and subtractor in order to reduce the value of the pixel in a very simple manner such that it takes very less amount of run time memory and the time required to encode and decode the given image is very much less. In this proposed method, decompressed image is exactly equal to that of the original image hence it is purely lossless method. Performance of this method is also compared with arithmetic operation based predictive lossless image compression based on time to compress and decompress and compression ratio as quantitative parameters. Since this is taking less time to encode and decode this is much suitable for real time implementation of image codec.

Keywords
Image compression, encoder, decoder and arithmetic operation.

1. Introduction

In general digital images contain lots of redundant information and hence they are usually compressed to remove redundancy, minimize the space required for storage or bandwidth for transmission particularly through wireless networks. If the redundancy removing process is reversible then the exact reconstruction of the original image can be achieved, it is called lossless image compression. In many scientific and medical applications and law enforcement (high performance applications) lossless image compression is the best choice. The techniques employed in lossless image compression are fundamentally rooted in entropy coding theory. Digital images very often have extremely high redundancy due to lesser variation of adjacent pixel values. Similarity can also be noticed in certain components or bit-planes of the image. The efficiency of the image compression algorithm depends on how fast and how best we can exploit this spatial redundancy and spectral redundancy. Various compression techniques have been developed for lossy [1, 2, 3, 8, 9, 10, 11] and lossless image compression [13, 14, 15, 16]. We proposed an efficient image compression algorithm that should yield higher levels of compression as compared to the JPEG standard and other lossless image compression, while ensuring no loss of the quality of image [5, 6, 8]. Main advantages of this proposed method is very simple in implementation and higher compression ratio and less time to compress and to decompress algorithm. This paper is organized as follows: Importance and procedural steps of wavelet transforms is explained in section II, proposed method for compression system is explained in III, Simulation results are presented in IV, Conclusion and future scope is given in V.

2. Existing Method with Illustration

In this proposed method, an image to be compressed is divided into non-overlapping blocks of size 2x2.Compression is achieved by representing each block by four different gray values corresponding to block size 2x2 which is
obtained by a partitioning based on block statistics. For every block B, let pixels are xl, x2, x3, x4 and the corresponding pixel intensities f(xi). Select the minimum intensity value of block B, say f(x3). Subtract f(x3) from the corresponding four pixel intensity values. Now if every block has same intensity, the block will be zero. If every block has two different intensity values, the block may have one value. The objective of this image compression technique that each block will have only one non-zero value or all are zero. It is desired that if four pixel are of different intensity value, then after consecutive maximum three subtraction the block will be one non-zero value or all are zero say, non zero intensity value f(x) and coordinate value is xi, yi. Every non-zero value is stored in dynamic dictionary (DD). Very dynamic dictionary has two entries, one position and second is value. For all block B, either one non-zero value (from DD) or zero value, it is stored in two dimensional array of size original image divided by block size. This is compressed image.
The existing method is illustrated with an example shown with the following steps for compression and decompression.
Steps involved in compression.
Step 1: Let us consider a matrix A, vector V1 and a matrix W

$$A=\begin{bmatrix}230 & 240\\ 220 & 210\end{bmatrix};\ V_1=[210]\ ;W=\begin{bmatrix}0 & 0\\ 0 & 210\end{bmatrix}$$

Step 2: C=A-B

$$C=\begin{bmatrix}20 & 30\\ 10 & 0\end{bmatrix}$$

Now consider the minimum value as vector V_2
$V_2=[10];$ W=W+V_2

$$W=\begin{bmatrix}10 & 10\\ 10 & 210\end{bmatrix}$$

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Step 3: $D=C-V_2$

$$D=\begin{bmatrix}10 & 20\\ 0 & 0\end{bmatrix}$$

Now consider the minimum value as vector V_3

$V_3=[10]$; $W=W+V_3$

$$W=\begin{bmatrix}20 & 20\\ 10 & 210\end{bmatrix}$$

Step 4: $E=D-V_3$

$$D=\begin{bmatrix}0 & 10\\ 0 & 0\end{bmatrix}$$

Now consider the minimum value as vector V_3

$V_4=[10]$; $W=W+V_4$

$$W=\begin{bmatrix}20 & 30\\ 10 & 210\end{bmatrix}$$

Steps for Decompression

$$W=\begin{bmatrix}20 & 30\\ 10 & 210\end{bmatrix}$$

The maximum value from the matrix is 210, adding this to all the three elements, we get:

$$A=\begin{bmatrix}230 & 240\\ 220 & 210\end{bmatrix}$$

The drawback of this method is more number of steps is involved. To reduce the number of steps a new method is proposed.

3. Proposed method

Aim of this proposed method is to reduce the number of steps required to compress the image without changing the quality of the image. In [17] author proposes a method of entropy based arithmetic image compression and decompression technique with more than nearly 12 steps and it requires so many arithmetic additions and subtractions, hence it will become complicate, particularly when it is implementing in hardware. The proposed Method-I reduces the number of steps required to come up with the same results. Hence it is more suitable for hardware implementation. Since it is taking less hardware, time required to compress and decompress the image is much less. Hence it is suitable for real time implementations.

A. Algorithm for proposed Method-I:

Step 1: Reading an image from the data base.
Step 2: Divide the image in to non-overlapping sub blocks of size 2X2.
Step 3: Find the nonzero minimum value of each sub block.
Step 4: Calculate the difference with non zero minimum value for the remaining three elements.
Step 5: Keep the nonzero minimum value in the same location without changing its value.

B. Algorithm for proposed Method -II:

Step 1:Take the output of the proposed Method-I
Step 2: Repeat all the steps 1-5 of proposed Method-I.
Step 3: Output of step 2 is the compressed image for storage and transmission.
Proposed Method-II surely will give us better compression ratio compared to proposed Method-I.

4. Illustration of Proposed Method

Let us consider a sub image of size 2×2, whose elements are shown in the following matrix A:

$$A=\begin{bmatrix}230 & 240\\ 250 & 210\end{bmatrix}$$

Non-zero minimum value of A is 210

All the remaining three elements in 'A' are subtracted with Non-zero minimum value of 210, we get

$$B=\begin{bmatrix}20 & 30\\ 40 & 210\end{bmatrix}$$

By adding 210 with all the three elements, we get

$$C=\begin{bmatrix}230 & 240\\ 250 & 210\end{bmatrix}$$

5. Simulation Results And Discussions

Simulation results of proposed Method-I clearly shows that the time required to compress and to decompress the given image is dramatically reduced, and at the same time decompressed image quality is exactly same as the original image as it is purely lossless method. In a proposed method-II time required is slightly increased as it is iterative and there is slight increase in compression ratio without compromising the quality of the decompressed image.

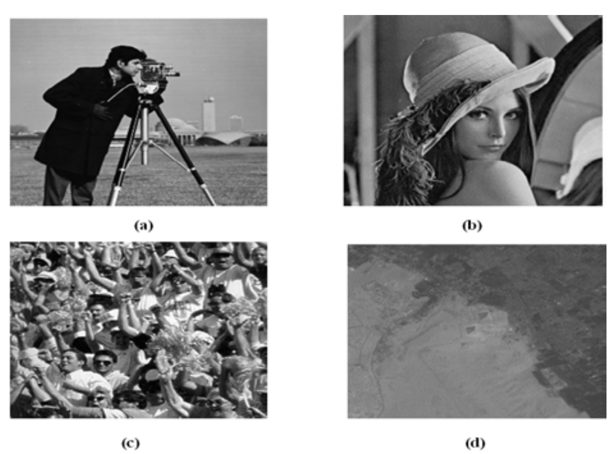

Figure 1: a to d shows the original images of Cameraman, Lena, Crowd and Giza

Table 1: Comparison of Simulation time & Compression Ratio for Various images

Image	Parameter					
	Simulation Time (Sec)			Compression Ratio		
	Existing Method	Proposed Method-I	Proposed Method-II	Existing Method	Proposed Method-I	Proposed Method-II
Cameraman	1.403	0.387	1.13	4.4	4.4	5.37
Lena	1.414	0.336	1.09	4.26	4.26	5.06
Crowd	1.48	0.478	1.29	4.1	4.1	5.13
Giza	1.421	0.422	1.24	4.3	4.3	5.24

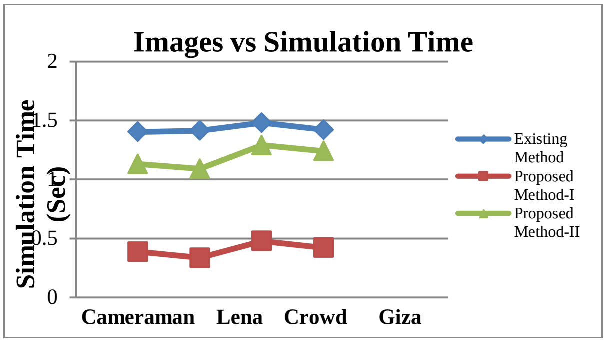

Figure 2: Comparison graph for Simulation time vs Images

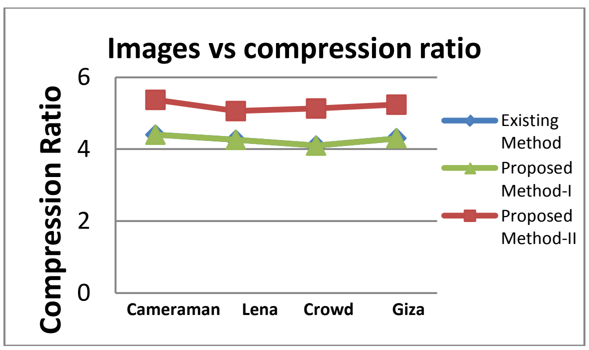

Figure3: Comparison graph for Compression ratio vs Images

Conclusion

Finally it is concluded that the proposed method-I and proposed method-II is giving better performance compared to existing methods with reference to time and compression ratio.

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