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Lossless Image Compression using an Efficient Huffman Coding

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Abstract: Lossless image compression is a technique to reduce the size of image without failure of its originality. It yields all its content while received an output image. There are different well known compression techniques offered to efficiently compress an image. Here an efficient work introduce for lossless compression named Huffman coding which is an efficient lossless compression technique. It is uncomplicated and proficient to implement and need lesser amount of memory space for store an image.

Keywords: Image compression, Lossless compression, Lossy compression, Huffman coding, Source Reduction

I. INTRODUCTION

Lossless compression is a technique to reproduce an accurate image exactly similar to the original. A new lossless method of image compression and Decompression using huffman coding techniques [1] describes detailed lossless method of compression and decompression using huffman coding. The execution of this method is easy to implement, simple and use minimum memory space. It describes how an image get compressed and also describes the various redundancy types including coding redundancy, inter pixel and psycho visual redundancy. The implementation of compression and decompression using Huffman coding is provided and the results shows that there is no information can loss while decompressed of image. Compression Using Huffman Coding [2] describes various techniques for compression such as simple repetition, RLE, pattern substitution, Entropy encoding, Shannon-fano algorithm, huffman and adaptive huffman coding. The main conception is to explain the basic technique of huffman coding algorithm. It includes the huffman coding characteristics, area of applications, advantages and disadvantages. Huffman Based LZW Lossless Image Compression Using Retinex Algorithm [3] proposes two lossless compression methodologies such as huffman coding and Lempel-Ziv-Welch(LZW) method. Huffman coding method is provide a huffman tree and performs encoding operation on input symbols.

Then use LZW for compression and finally it use retinex algorithm on compressed image for improve image quality. Energy Aware Lossless Data Compression [4] illustrates various data compression methods for lossless and their performance on image. It can be estimate the compression ratio and also calculate the time for compression and decompression of image when using various compression algorithms. Simple Fast and Adaptive Lossless Image Compression Algorithm [5] explains lossless methods and proposes an algorithm named as an SFALIC.

The compression ratio of SFALIC was examined the similarities and differences between the various image compression algorithms. Lossless Image Compression Technique Using Combination Methods [6] describes lossless method LZW and Bose, Chaudhuri, and Hocquenghem (BCH) and compare those yield compression ratios with RLE and huffman coding and some other lossless compression method. Lossless image compression algorithm for transmitting over low bandwidth line [7] proposes a new efficient lossless compression algorithm based on Bayer format image. It uses adaptive wavelet decomposition method and explains huffman coding method. The results shows an adaptive wavelet decomposition is works better than non-adaptive wavelet decomposition. Lossless image compression [8] explains different linearization schemes using Huffman, arithmetic and LZW. It uses the spatial domain algorithms. The experimental results shows the image performance when using various compression methods. Lossless Compression of Continuous-Tone Images [9] describes some current advantages of continuous-tone images than other images. It uses different coders such as JPEG-LS, CALIC and FELICS (Fast, Efficient Lossless Image Compression System). A Literature Survey on Lossless Image Compression [10] describes a basic concept and procedure for a condensed image. Lossy and lossless compression using various algorithms [11] describes the different lossy compression and lossless compression techniques and applies those various algorithms on compound images and calculates Peak Signal to Noise Ratio (PSNR) for those various compound images. Section II defines an image compression and their categories lossy method and lossless compression method. Section III describes the operations of huffman encoding and decoding. It defines the average length and code efficiency of huffman code. In Section IV conclusion is drawn.

II. IMAGE COMPRESSION

Image Compression is a technique to diminish the amount of data without any degradation in an image quality. So the image should requires less memory for store, it leads to some more images have stored in those memory space. Image compression is widely used for transmission of image over internet and storage. The necessity of image compression is to decreasing the image transmission time. This means every image took some time for transmitting via internet, but compressed image took less time than uncompressed image transmission time. There are two types of Compression namely lossy compression and lossless compression.

A. Lossy Compression

Lossy image compression is a technique which offers reducing of data efficiently. It does not reproduce an original image. It can only trying to recuperate an approximation of original image. So thus the resultant image should be smaller and has lower quality. It is also known as irreversible compression. It is mostly used in multimedia data.
It consists of the following techniques.

1) Predictive Coding
2) Transform Coding
3) Wavelet Coding

B. Lossless Compression

Lossless image compression is a technique to reproduce a precisely accurate image. so thus the resultant image should be larger and has higher quality. It consists of the following techniques. It is also known as reversible compression.

1) Variable Length coding
a) Huffman coding
b) Arithmetic coding
2) Bit Plane coding
3) Lempel-Ziv-Welch coding
4) Lossless Predictive Coding
5) Differential Pulse Code Modulation (DPCM)

III. HUFFMAN CODING

The popular method for eliminating some pixel values more common than others is called Huffman coding. The principle of huffman coding is performs to encode the data presented in an image and those data encodes are stored in a code book.
Huffman encoding algorithms performs encoding operations on an input symbols and their frequency of a list of nodes. The list of nodes having probabilities of P(Xi) where i=1,2,…L. A table which has a source symbols and the number of times they occurred is called a frequency table. It can be used to construct a huffman tree having a list of nodes. The encoding process of huffman tree starts from root node to leaf node. Each and every node of huffman tree consisting of input symbols and their respected frequency, a pointer that pointed to the parent node and child nodes. Find the very lowest probabilities of two nodes in a list and going to adding them. The entire huffman tree is involve to encoding process, causes to generates a new node. That the new node has been consider as a parent node to the two child nodes. At last it will eliminate the new node childrens from a tree and including the new parent node. Continue this process and then terminate if there is only one node without a parent node. This one node will play as a root node of the entire tree. The parent node will assign a bit to left and right child node.A bit 0 is assigned to the left child node and a bit 1 is assigned to the right child node. The process of decoding a huffman tree starts from child node to root node.
One example is given here. A list of nodes consists of 0, 2, 14, 136, and 222 symbols. Their frequency occurrences are given in Table 1. The table shows, symbol 0 occurs 50 times in the list. The Huffman tree and their final code are shown in below.

SYMBOLS	FREQUENCY
0	50
2	9
14	8
136	6
222	4

Table 1: Frequency of Input Source Symbols.

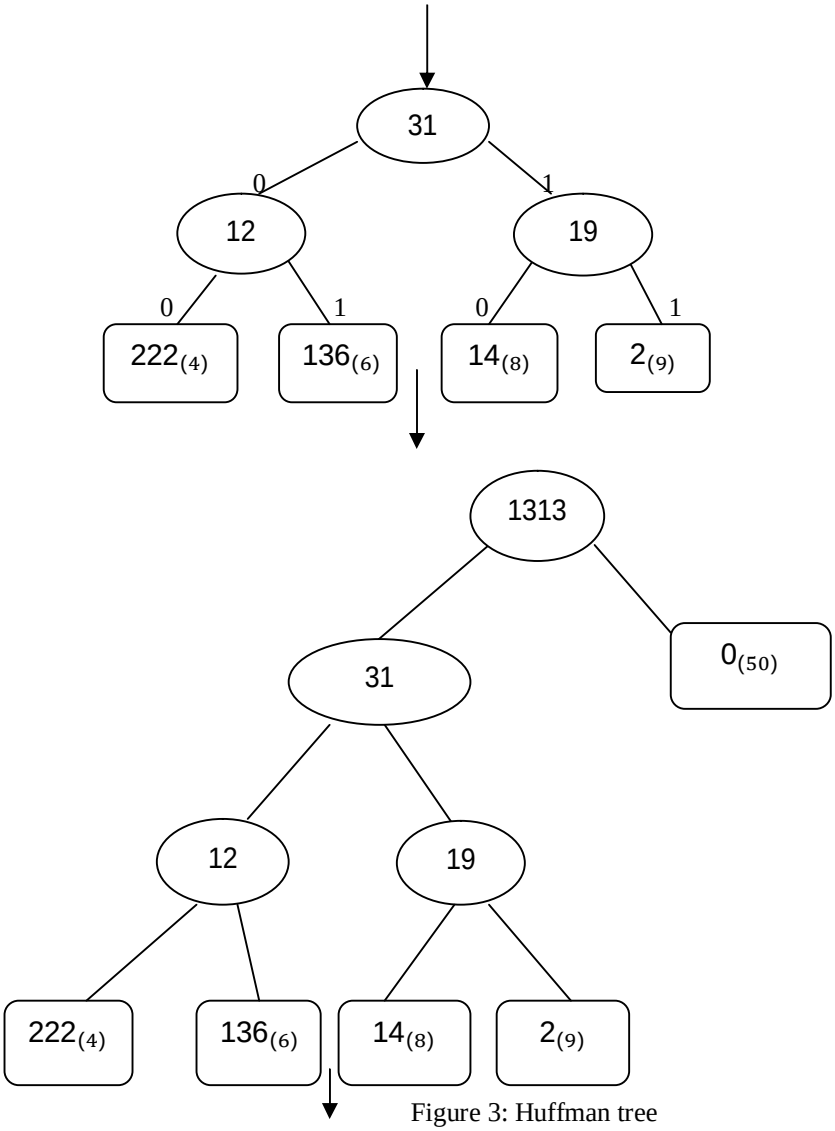

Figure 3: Huffman tree

SYMBOLS	CODE	FREQUENCY
0	1	50
2	011	9
14	010	8
136	001	6
222	000	4

Table 2: Symbols with their Codes

A. Steps In Huffman Coding

1) Construct a node list with input symbols and their frequency of symbols .
2) Search the two nodes which has lowest probabilities in the list.
3) Consider those two nodes as the children of a new node which has a probability by adding those two lowest probabilities.
4) These children of a new node has take away from the list of nodes and include the new parent-node.
5) Do the same procedure from step 2 to step 4 until the list consists of only one node without a parent node.

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An example is given here to explain each steps in Huffman coding algorithm. A list of nodes having symbols and their probability is given. To construct a Huffman table by arrange the given probabilities from very large to small value and adding the least two values. Do this method until a table has two values.

Source		Reduction of Source			
Symbol	Probability	I	II	III	IV
b2	0.4	0.4	0.4	0.4	0.6
b1	0.3	0.3	0.3	0.3	0.4
b3	0.1	0.1	0.2	0.3	
b4	0.1	0.1	0.1		
b6	0.07	0.1			
b5	0.03				

In the above table, first source reduction is done by adding 0.07 and 0.03 i.e., 0.07+0.03=0.1 .So in a I column of Huffman reduction table, write 0.1 instead of 0.07 and 0.03. Then combining 0.1 and 0.1 and write the value in IInd column i.e., 0.1+0.1=0.2 as a 3rd value. Similarly to do reduction in IIIrd column. In IVth column, there is only two values. So reduction can stop. Next to assign a code for each value. The code assignment procedure table is given below.

Source			Source reduction							
			I		II		III		IV	
Symbol	Probability	Code								
b2	0.4	1	0.4	1	0.4	1	0.4	1	0.6	0
b1	0.3	00	0.3	00	0.3	00	0.3	00	0.4	1
b3	0.1	011	0.1	011	0.2	010	0.3	01		
b4	0.1	0100	0.1	0100	0.1	011				
b6	0.07	01010	0.1	0101						
b5	0.03	01011								

In above table assign 0 to 0.6 and 1 to 0.4 in Column IV. In column III assign 1 to 0.4 that is already consigned in column IV and allocate 0.6 in column IV is created by 0.3 and 0.3 in column III. So assign 0 to 0.3 and 0.3 and append 0 and 1 after the 0 of two values 0.3 and 0.3. Do the same procedure till Ist column to obtain the Huffman code.

A multiplication of symbols probability and the number of encoded bits is called as the average length of the huffman code (L_{avg}). It can be calculated as beow.

L_{avg} = (probability of source symbols) x (number of bits)

= (0.4x1) + (0.3x2) + (0.1x3) + (0.1x4) + (0.07x5) + (0.03x5)

=2.2 bits/symbol

If the source entropy is 3.14 bits/symbol then the code efficiency is,

Efficiency = 3.14/2.2 = 1.4272727

IV. CONCLUSION

Lossless compression is an efficient method of compressed a given image without any failure of its original information in a resultant image. It will look same as the original. A future work may involve to introduce some other efficient lossless compression method for improving an image code efficiency by reduction of more bits while compressed.

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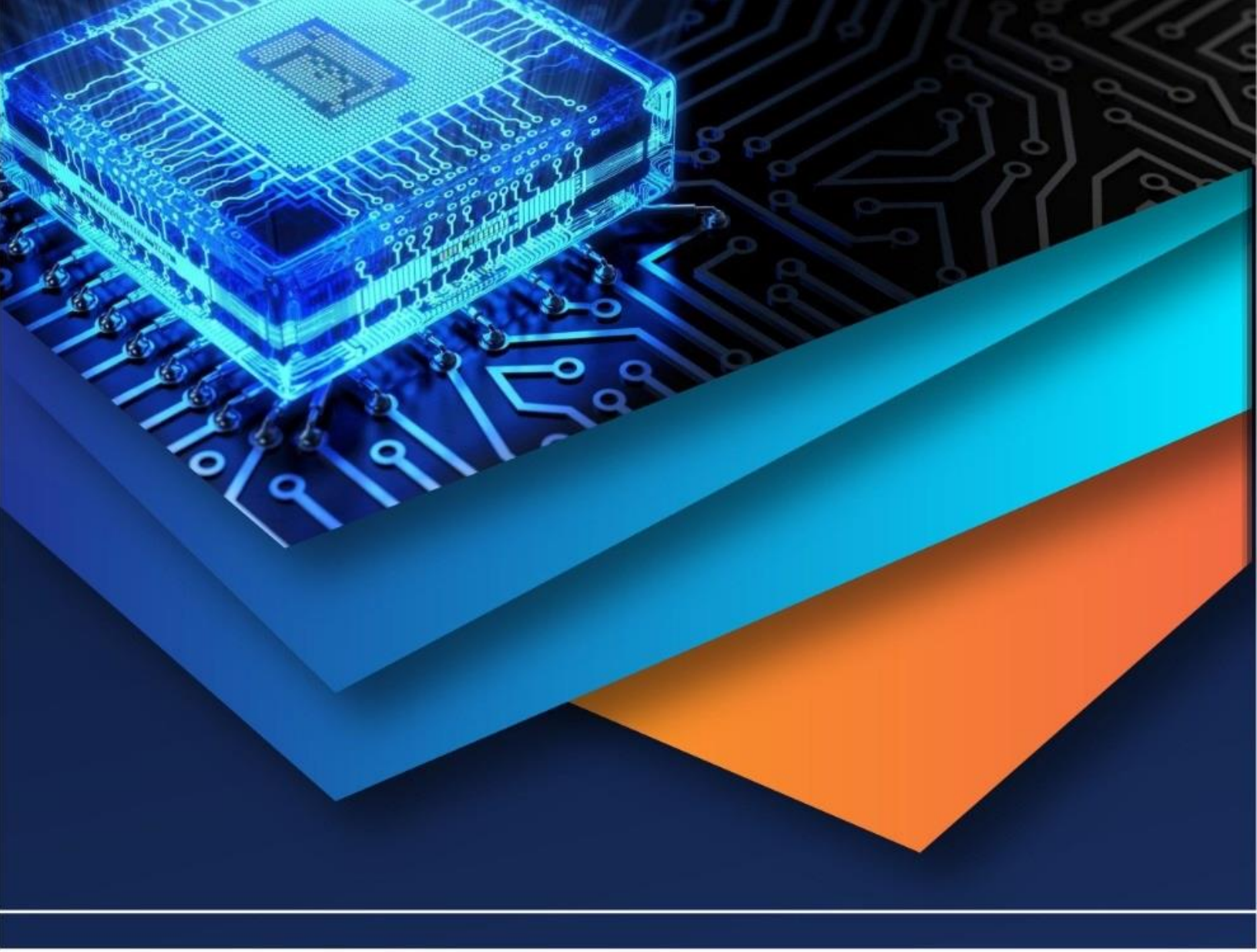

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