Huffman Coding Based Lossless Image Compression Method with High SNR

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Abstract: **Compression is used about everywhere. Images are very important documents nowadays; to work with them in some applications they need to be compressed, more or less depending on the purpose of the application. There are various algorithms that performs this compression in different ways; some are lossless and keep the same information as the original image, some others loss information when compressing the image. In this paper I have been working with Huffman lossless compression algorithms for different grayscale images. I have seen how well the different format work for each of the images. The compression ratio (CR) and peak signal to noise ratio (PSNR) are obtained for different images.**

Keywords: **Lossless compression; compression ratio (CR); peak signal to noise ratio (PSNR)**

I. INTRODUCTION

Image compression is the application of data compression on digital images. In effect, the objective is to reduce redundancy of the image data in order to be able to store or transmit data in an efficient form [1]. Data compression has become requirement for most applications in different areas such as computer science, Information technology, communications, medicine etc. In computer science, Data compression is defined as the science or the art of representing information in a compact form [2]. Digital image compression techniques can be divided into two classes: lossless and lossy compression. Currently two basic classes of data compression are applied in different areas. In lossless compression, every single pixel that was originally in the image remains same after the image is uncompressed. All of the information is completely stored. Lossy compression reduces the size of the image by permanently eliminating some redundant information. Reconstructed image contains degradation to the original image. The main objective of this paper is to compress images by reducing number of bits per pixel required to represent it and to decrease the transmission time for transmission of images and reconstructing back by decoding Huffman algorithm.

II. COMPRESSION PRINCIPLE

A common characteristic of most of the images is that the neighbouring pixels are correlated and therefore contain redundant information. The foremost task then is to find less correlated representation of the image. Two fundamental components of compression are redundancy and irrelevancy reduction. a. Redundancy reduction aims at removing duplication forms of the signal (Image/Text). b. Irrelevancy reduction omits parts of the signal that will not be noticed by signal receiver, namely the Human visual system.

In an image there are three types of redundancies in order to compress file size. They are:
a. Coding redundancy: Fewer bits to represent frequently occurring symbols.
b. Interpixel redundancy: Neighbouring pixels have almost same value.
c. Psyco visual redundancy: Human visual system cannot simultaneously distinguish all colours.

A. Compression advantages of variable length coding over fixed length coding: Fixed length coding assign equal length code bits to every symbol irrespective to the number of occurrences. This method gives a constant compression to the data set. Additionally the decoding time for symbol is also uniform. This results in the slow coding system under large data processing.
Whereas variable length coding will assigns variable length code word to the symbols of set. In variable length coding compression takes place based on using shorter code words for symbols that occur more frequently and longer code word to less occurring symbols. This results in higher compression of data set with the reduction in decoding time when compared to fixed length coding. The commonly used fix length coding techniques are run length coding, gray coding etc. Huffman coding, Arithmetic coding are few examples of variable length coding. The most commonly used variable length coding is Huffman coding which is lossless.

B. Huffman coding: Huffman coding is classical data compression techniques invented by David Huffman. It is optimal prefix code generated from set of probabilities and has been used in various compression applications. These codes are of variable code length using integral number of bits. This idea causes a reduction in the average code length and thus overall size of compressed data is smaller than the original. Huffman's algorithm provided the first solution to the problem of constructing minimum redundancy codes. The compression process is based on building a binary tree that holds all symbols in the source at its leaf nodes and with their corresponding probabilities at the side.

III. IMPLEMENTATION OF HUFFMAN COMPRESSION ALGORITHM

Huffman code procedure is based on the two observations:

a. More frequently occurred symbols will have shorter code words than less frequently.

b. The two symbols that occur least frequently will have the same length.

The Huffman code is designed by merging the lowest probable symbols and this process is repeated until only\ two probabilities of two compound symbols are left. Thus a code tree is generated and Huffman codes are obtained from labelling of the code tree.

A. Development of Huffman algorithm

Step 1: Read the image on the workspace of matlab.

Step 2: Call a function which will find the symbols (i.e. pixel value which is not repeated).

Step 3: Call a function which will compute the probability of each symbol.

Step 4: Probability of symbols are arranged in decreasing order and lower probabilities are merged. This step is continued until only two probabilities are left and codes are assigned according to rule that, highest probable symbol will have a shorter length code.

Step 5: Further Huffman encoding is performed i.e. mapping of code words to the corresponding symbols will result in compressed data

Step 6: The original image is reconstructed i.e. decompression is done using Huffman decoding.

Step 7: Match the code words with code dictionary to get the reconstructed image.

The flow of this code is as below

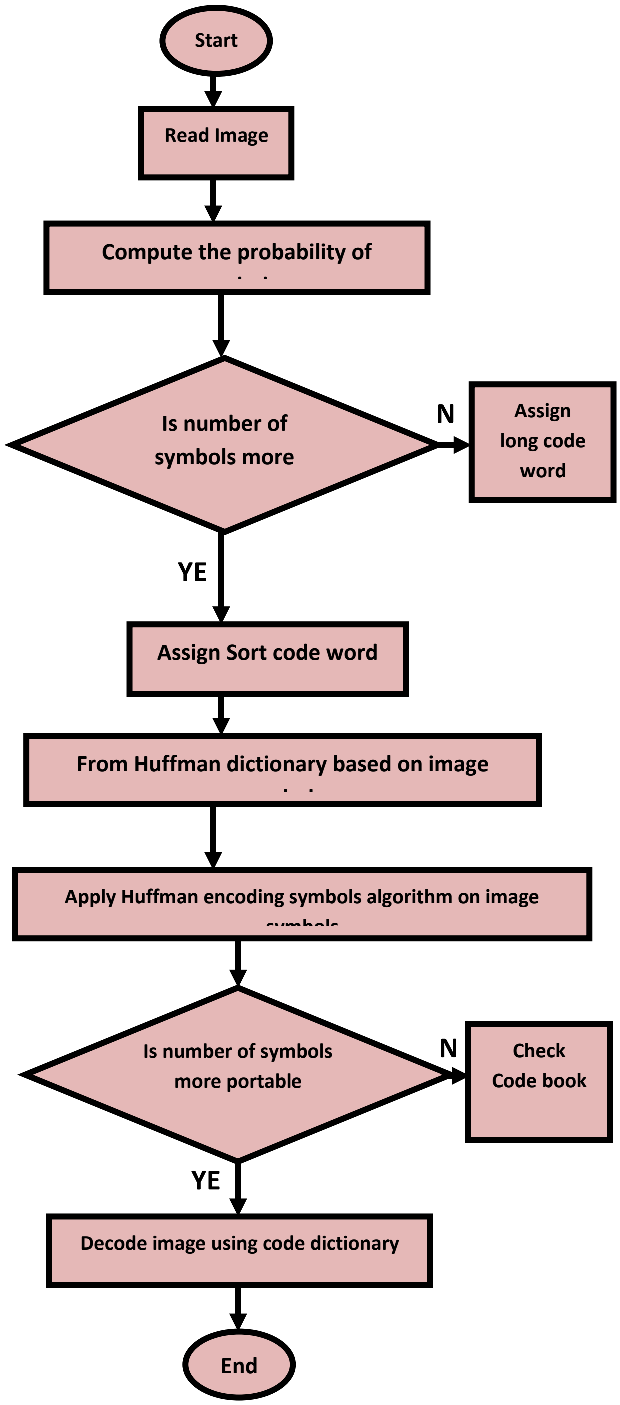

Figure 1: flow chart of proposed work

B. Performance Parameter

1. Compression Ratio (CR): Compression ratio (CR) is defined as number of bit to represent the size of original image to the number of bit to represent the size of compressed image.

Compression ratio shows that how much time the image has been compressed.

$$CR=\frac{\sum\sum\sum \text{Orignal}_{(r,c,f)}}{\sum\sum\sum \text{Reconstucted}_{(r,c,f)}}$$

To determine the distortion in the image with reference to original image, some quality measurement matrices can be applied. The following are the most commonly used measures.

2. Peak Signal To Noise Ratio (PSNR): The PSNR is most commonly used as a measure of quality of reconstruction of image. A higher PSNR would normally indicate that the reconstruction is of higher quality.

$$\text{PSNR} = 20\log\frac{256^2}{\text{MSE}}$$

3. Mean Square Error (MSE) : The MSE is the cumulative squared error between the compressed and the original image.

$$\text{MSE} = \frac{\sum_{r=1}^{M}\sum_{c=1}^{N}(X_{(r,c)} - Y_{(r,c)})^2}{r * c}$$

Where X and Y are the images between which MSE is been measuring and 'r' is the number of rows and 'c' is the number of column, M is the total Rows image and N is the total number of columns.

A lower value of MSE means lesser error as seen from the inverse relation between the MSE and PSNR.

4. **Entropy (H):** The entropy of a symbol is defined as the negative logarithm of its probability. To determine the information content of a message in bits we express the entropy.

$$H = -\sum_{i=1}^{N}(\text{Pi}\log_2 \text{Pi})$$

Here Pi is the occurrence probability of symbol Si . In compression, entropy determines how many bits of information are actually present in a message.

IV. SIMULATION RESULT

Figure 2 GUI: Huffman algorithm performance measure

We have developed Huffman algorithm for image and analyzed performance parameter like PSNR, MSE, CR and Entropy. Simulation results show the lossless image compression scheme. After running the algorithm on grayscale Rose1 image in Fig.2

Our PSNR value is 79.4787.45dB, CR is 0.104216 as shown in figure.

V. CONCLUSION

We proposed the Huffman image compression algorithm. We applied this algorithm on different images. The experimental results for PSNR are between 64.8902 dB to 79.4787.83 dB and we achieved highest CR up to 1.82. The reconstruction of image is near lossless with Huffman algorithm.

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