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Hybrid Image Compression Using DCT

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ABSTRACT: Image compression is used to reduce redundancy and irrelevance of the image data, it is also used for archiving the data which has a very broad usage in various fields like compressing medical images. Image compression may be lossy or lossless. In this paper, we introduce a system for hybrid image compression where the lossy and the lossless techniques are combined to get a better compression ratio. This hybrid technique will be used to compress a set of grayscale medical images. First a lossy technique is applied on the image followed by lossless technique to compress the image and the results obtained for various combinations are compared. The results comprises of the compression ratio and the percent of compression of the medical images. For lossy we are using Discrete Cosine Transform (DCT)and for lossless we will be using Run Length Encoding (RLE), Huffman and Lempel-Ziv-Welch (LZW). For Hybrid image compression, the first hybrid technique is a combination of DCT followed by RLE and Huffman and the second hybrid technique is DCT followed by RLE and LZW.

KEYWORDS: Image Compression; Lossy; Lossless; DCT; RLE; Huffman; LZW; Hybrid Compression

I. INTRODUCTION

Image compression is minimizing the size in bytes of a graphics file without degrading the quality of the image to an unacceptable level. The reduction in file size allows more images to be stored in a given amount of disk or memory space. It also reduces the time required for images to be sent over the Internet or downloaded from Web pages.

Image contains large amount of data hidden in them, which is highly correlated and therefore contain redundant information. This project presents algorithms for image compression consisting of a combination of lossy and lossless methods.

Hybrid image compression includes a combination of Lossy and Lossless methods [1]. The lossy compression method includes the Discrete Cosine Transform (DCT) algorithm whereas the lossless compression method will include Huffman[1], LZW and RLE[2] algorithms and the output will be the compressed image. This hybrid compression is applied on grayscale medical images. The algorithms will be differentiated based on statistical parameters (CR, Space Saving and Time).

It provides a system in which the user can select the medical images that he/she wants to compress and the combination of the compression algorithms (either DCT+RLE+Huffman or DCT+RLE+LZW) that the user wants to apply on those images. Firstly it will compress the input images according to the hybrid technique selected by the user. Secondly, all the statistical parameters of the compressed image will be recoded and thus the various combinations of compression techniques can be compared for efficiency with different types of medical images.

II. RELATED WORK

In [1] the authors presents a comparative study has been carried out on image compression using DCT(Discrete Cosine Transform) and DWT(Discrete Wavelet Transform). An algorithm for image compression which consist of a combination of lossy and lossless methods which are based on a discrete wavelet transform and apply entropy coding as a lossless compression with using a quantization and thresholding techniques to produce a high compression ratio and high quality of image is presented by the author in [2]. In [3] the author presents a new image compression scheme

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with pruning proposal based on discrete wavelet transformation (DWT).The effectiveness of the algorithm has been justified over some real images, and the performance of the algorithm has been compared with other common compression standards. In [4] a research on a new and very competent image compression scheme is proposed by the authors which is based on discrete cosine transform that results less computational complexity with no sacrifice in image quality. The performance of the proposed algorithm has been compared with some other common compression standards.

III. HYBRID COMPRESSION

A. Discrete Cosine Transform (DCT) Method:

In our proposed method, DCT is used to compress the image. DCT is a technique for converting a signal into elementary frequency components and is widely used in image compression. DCT helps to separate the image into parts (or spectral sub-bands) of differing importance (with respect to the image's visual quality). DCT is applied to every non overlapping block of the image. It is described in the following equation:

$$F(m,n)=\frac{2}{L}C_mC_n\sum_{i=0}^{L-1}\sum_{j=0}^{L-1}f(i,j)\cos\left(\frac{(2i+1)m\pi}{2L}\right) .\cos\left(\frac{(2i+1)n\pi}{2L}\right) \quad (1)$$

Where $m,n=0,1,\ldots L-1$ and

$$C_k=\begin{cases}1/\sqrt{2}, & k=0\\ 1, & k\neq 0\end{cases}$$

DCT operation reduces the entropy of all images. The reduction in entropy becomes more profound as the number of retained coefficients is decreased. DCT renders an excellent energy compaction for correlated images. DCT stores energy in the low frequency regions. It also provides optimal de correlation for such images. Hence, all the uncorrelated transform coefficients can be encoded independently without compromising coding efficiency. Therefore, some of the high frequency information can be discarded without significant quality degradation. In quantization, further reduction of the entropy takes place or reduction in the average number of bits per pixel takes place. Inter pixel redundancies have been exploited by DCT to render excellent de correlation for the natural images. Symmetry is an extremely useful property of DCT as it implies that the transformation matrix can be pre computed offline and then applied to the image which provides improvement in computation efficiency. Orthogonality property of DCT will reduce the pre-computation complexity.

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This can be explained with the help of this figure.

Figure 1.a) Original Image b) Corresponding DCT compressed image of the original image

B. *Run Length Encoding (RLE):*

The Run Length Encoding (RLE)[2]is one of the two lossless methods which is used for compressing the image. RLE or Run Length Encoding is also called as recurrence coding[2]. It is very effective for the data sets which contain a lot of long sequences of repeated data and hence it can be used for compressing the grayscale images efficiently yielding good results. This algorithm consists of replacing large sequences of repeating data with only one item of this data followed by a counter showing how many times this item is repeated. For Example:

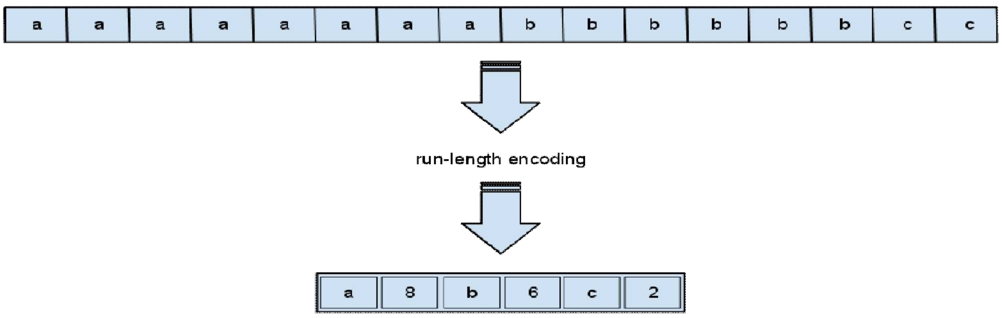

Figure 2. RLE Example.

C. *Huffman:*

The Huffman coding[1, 4] is the second lossless compression method which will be applied to compress the image after RLE and this will be our first hybrid technique which is implemented to compress the grayscale medical images. Huffman coding was proposed by Dr. David A. Huffman in 1952. It is applicable to many forms of data transmission. Huffman coding is a form of statistical coding and works well for text and fax transmissions. Huffman coding is a lossless data compression algorithm.[4] The idea is to assign variable-length codes to input characters, lengths of the assigned codes are based on the frequencies of corresponding characters. The most frequent character gets the smallest code and the least frequent character gets the largest code. The variable-length codes assigned to input characters are Prefix Codes, means the codes (bit sequences) are assigned in such a way that the code assigned to one character is not prefix of code assigned to any other character[4]. This is how Huffman Coding makes sure that there is no ambiguity when decoding the generated bit stream.

There are mainly two major parts in Huffman Coding:

1) Build a Huffman Tree from input characters.

2) Traverse the Huffman Tree and assign codes to characters.

D. Lempel-Ziv-Welch (LZW):

The Lempel-Ziv-Welch (LZW)[5]is the lossless compression method which will be applied to compress the image after RLE and this will be our second hybrid technique which is implemented to compress the grayscale medical images.

Lempel-Ziv-Welch (LZW) is a universal lossless compression algorithm created by Abraham Lempel, Jacob Ziv, and Terry Welch. LZW starts out with a dictionary of 256 characters (in the case of 8 bits) and uses those as the "standard"

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character set. It then reads data 8 bits at a time (e.g.,'t', 'r', etc.) and encodes the data as the number that represents its index in the dictionary. Everytime it comes across a new substring (say, "tr"), it adds it to the dictionary; everytime it comes across a substring it has already seen, it just reads in a new character and concatenates it with the current string to get a new substring. The next time LZW revisits a substring, it will be encoded using a single number. Usually a maximum number of entries (say, 4096) is defined for the dictionary, so that the process doesn't run away with memory. Thus, the codes which are taking place of the substrings in this example are 12 bits long (2^12 = 4096). It is necessary for the codes to be longer in bits than the characters (12 vs. 8 bits), but since many frequently occuring substrings will be replaced by a single code, in the long haul, compression is achieved.

IV. PROPOSED ALGORITHM

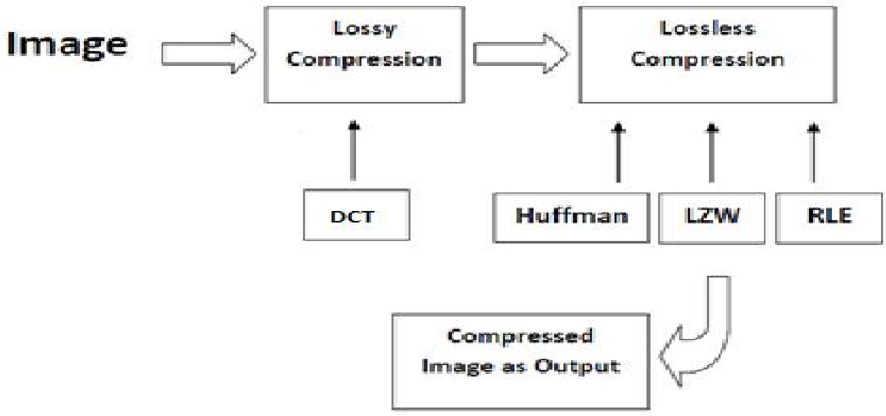

Figure 3. Block Diagram of Proposed Algorithm.

In this paper, we propose two hybrid methods which combines lossy and lossless compression to reduce the redundancy of the grayscale medical images, the first hybrid method combines DCT followed by RLE and Huffman and the second hybrid method combines DCT followed by RLE and LZW.

The algorithm steps for the proposed hybrid technique proposed in this paper are as follows:

- Input: Original Image(in .bmp format)
- Output: Compressed Image.

Step 1: Read the set of input grayscale medical images.
Step 2: If images are colored images then convert them to grayscale.
Step 3: Now, Thresholding is done using a threshold value which is selected and applied for wavelet transformed values. In this, the values which are less than or equal the threshold value is set to zero[2].
Step 4: Next, the DCT algorithm is implemented by using quantization of the DCT coefficients. This is done by rounding the coefficients. This completes the lossy part of compression using DCT.
Step 5: Now, we implement the lossless part of the hybrid technique in which first we will apply the Run Length Encoding (RLE)[2].
Step 6: After RLE, Huffman is applied to the output of the RLE to finally complete the first hybrid technique. For, the second hybrid technique, LZW is applied to the output of the RLE. This completes the process of hybrid compression and a compressed image is obtained as the output.
Step 7: The Compression Ratio and the Percentage of compression is calculated for each image.
Step 8: End.

V. EXPERIMENTAL RESULTS

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Here, the effectiveness and the efficiency of the two proposed hybrid compression techniques has been illustrated by the various experimental results which are obtained. The proposed hybrid compression has been implemented in MATLAB and the grayscale medical images are used to evaluate each of the proposed technique. The compression ratio (CR)[1, 3] and the percentage of compression is calculated for each image and the results can be seen in the following table where the two proposed techniques can be compared and evaluated for compressing grayscale medical images.

Table 1. Compression Ratio for 30 Images.

Column	DCT	DCT+RLE	DCT+RLE+Huffma	DCT+RLE+LZ
Image No	Compression ratio	Compression Ratio	Compression ratio	Compression ratio
1	3	18.83398793	35.32938005	74.10780249
2	3	13.64196503	25.53682296	64.99438017
3	3	11.32860847	20.35068833	58.15084295
4	3	9.236059567	16.384	56.22190449
5	3	7.958549223	14.11805256	50.92152292
6	3	7.945041623	14.04142265	50.24482494
7	2	7.266706091	12.98771304	50.33486943
8	2	7.303146243	13.0229847	47.70880854
9	3	6.526190002	11.64463397	46.31519435
10	3	6.865763375	12.69585432	46.68914747
11	3	5.990128572	10.91296625	45.88284714
12	3	6.035363458	11.08837629	45.24925201
13	3	6.152074598	11.37580281	45.61670534
14	3	5.854564946	10.70849673	45.0419244
15	2	5.702749739	10.34833412	44.07262946
16	2	6.200580295	11.62466742	44.48144796
17	2	6.073584381	11.36725254	44.52173913
18	2	5.930859729	11.02680875	44.6734833
19	2	6.001465201	11.13295583	44.26114363
20	2	6.007149623	11.36659536	43.56481276
21	2	5.991041229	11.36462428	43.86613119
22	3	5.994694637	11.4028535	44.28108108
23	3	8.812155439	20.35068833	46.31519435
24	3	6.035363458	10.70849673	45.61670534
25	3	5.854564946	10.34833412	45.0419244
26	3	5.702749739	11.62466742	44.07262946
27	3	5.930859729	11.36725254	44.52173913
28	3	6.007149623	11.13295583	44.26114363
29	3	5.994694637	11.36659536	43.86613119
30	3	8.812155439	11.36462428	44.28108108

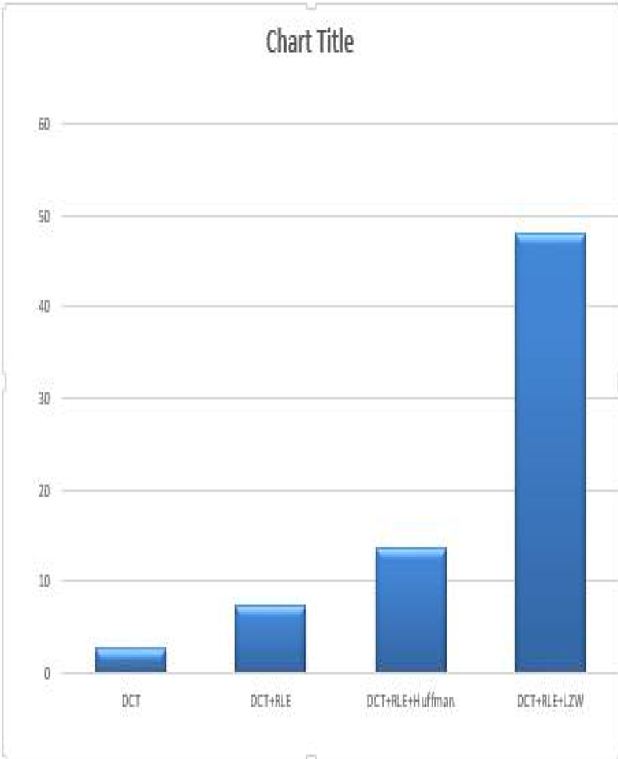

Figure 5. Chart Showing Average CR for 30 Images.

The table above shows the compression ratio of the two proposed techniques for each image and also, it shows the compression ratio of other compression techniques which are DCT and DCT+RLE but you can observe in the table that the proposed hybrid techniques are showing better results. The figure is the graphical representation of the results table and you can compare the efficiency of the various techniques by referring to the graph.

VI. CONCLUSION

In this paper, a hybrid technique for image compression has been described. This is an image compression system which includes a combination of lossy and lossless techniques. The lossy compression method will includes Discrete Cosine Transform (DCT)algorithm whereas the lossless compression method includes Huffman, LZW and RLE algorithms and the output is a compressed image. The first hybrid technique is a combination of DCT followed by RLE and Huffman and the second hybrid technique is DCT followed by RLE and LZW .This hybrid compression is applied on grayscale medical images. The Compression ratio and the percent of compression of each image is calculated. From the observation of the experimental results obtained in the above table, it can be concluded that the hybrid technique DCT+RLE+LZW showed good performance in compressing the medical images.

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