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Various Image Compression Methods: A Survey

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Abstract:
Every day, a massive amount of information is stored, processed, and transmitted digitally. Image compression will allow Picture Archiving and Communication Systems (PACS) to detract the sizes of files on their storage necessities while maintaining relevant information. This paper represents various compression methods as it is applicable to various fields of image processing. On the basis of analyzing many techniques are available for compressing the images. But in some cases these techniques will reduce the quality and originality of the image. There are basically two types of methods are exist, namely lossless and lossy image compression techniques. In present time some other methods combine with basic method.

Keywords: *Compression, Lossless, Lossy, Redundancy, DCT*

1. Introduction

Pictures have been with us since the dawn of time. An image can be stored in any representation, provided there is an algorithm that can convert it to a form usable by a display. This process of changing the representation of an image is called image coding and if the result uses less storage space than the original it is called image compression. Today, Image compression is the very important and widely used field in DIP (Digital image processing). Image compression is playing a key role in the development of various multimedia computer services and telecommunication applications. Images play an important role in the world of graphics and multimedia. Its transmission with storage has become really a big burden as it occupies more space in memory. So, the goal of image compression is to create smaller files that use less space to store and less time to send. Image compression techniques aim to remove the redundancy present in data in a way that makes image reconstruction possible. In view of the growing energy requirements of wireless data services, the volume of multimedia data being transmitted over wireless channels may be reduced using various compression techniques. A compression method consists of definitions of two complex processes compression and decompression. Compression is a transformation of original data representation into a different representation characterized by a smaller number of bits. Compression can be classified into two types Lossy and Lossless compression. In Lossless compression there is no information loss and the image also retains its quality it can be remodeled exactly the same as the original. Lossless compression methods are mainly used in telemedicine application. In Lossy compression loss and missed information is bearable. The application is a commercial distribution (DVD). Lossless methods cannot provide enough compression ratios.

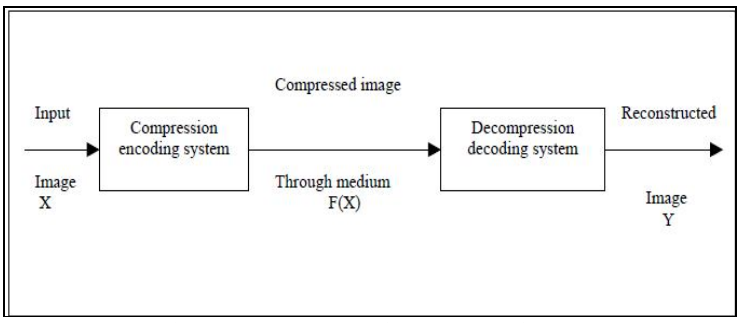

Figure 1: Basic Data Compression System

2. Advantage of Image Compression

- Redundancies deficiency aims at removing duplication from the signal source.
- It provides an eventual expense savings involved with sending less data over the switched telephone network.
- It provides a level of protection against illicit monitoring.
- Compression of image not only reduces storage requirements but also overall execution time.

3. Fundamental of Image Compression

Image compression addresses the issue of reducing the quantity of information in need to represent a digital image. Every image contains redundant data. Redundancy means the duplicating of data in the image. The image compression eventuates by taking advantage of redundant information of in the image. Reduction of redundancy provides helps to achieve a saving of storage space of an image.

There are mainly three types of redundancy:-

3.1. Inter Pixel Redundancy

Inter pixel redundancy is a form of data redundancy, which is related to inter pixel correlation inside an image. Usually the value of a few pixels in the image can be reasonably predicted from the values of a group of other pixels in the image. For example the gray levels of neighboring pixels are roughly the same and by knowing the gray level value of one of the neighboring pixels one has a lot of information about gray levels of other neighborhood pixels. Thus the value of the individual pixel carries a relatively small amount of information and much more information about pixel value can be inferred on the basis of its neighbors' values. This type of dependencies among pixels in the image is known as inter pixel redundancy. An example of this type of redundancy is Run Length Coding (RLE).

3.2. Coding Redundancy

This type of redundancy occurs when less than optimal code words are used. It is a type of coding that is always reversible and is usually implemented using look-up tables (LUTs).Examples of image coding schemes that explore coding redundancy are the Huffman codes and the arithmetic coding technique.

3.3. Psycho Visual Redundancy

Several experiments on the psycho physical aspects of human vision have proven that the human eye does not respond with equal susceptibility to all incoming visual information; some pieces of information are more important than others. Psycho visual redundancy arises due to the problem of perception. Our eyes are more responsive to slow and gradual changes of illumination than perceiving finer details and rapid changes of intensities. Unlike coding redundancy and inter pixel redundancy, psycho visual redundancy is concerned with real or quantifiable visual information. The elimination of psycho visual redundant data results in a loss of quantitative information. Thus, it is an irreversible process. The Discrete Cosine Transform (DCT) based algorithm at the heart of the JPEG encoding standard is based on this type of redundancy.

4. Image Compression Techniques

A compression method consists of definitions of two complex processes compression and decompression. Compression is a transformation of original data representation into a different representation characterized by a smaller number of bits. Contrary process reconstruction of the original data set is called decompression. On the bases of our necessity compression techniques are broadly bifurcated in following two categories:

- Lossless image compression
- Lossy image compression

4.1. Lossless Image Compression

As the name indicates lossless image compression method exploit redundancies without incurring any loss of data. In lossless compression methods, the data set reconstructed during decompression is identical as the original data set. This is one of the appropriate methods for reducing file sizes that can be applied to both image and audio files. Lossless compression basically tends to rewrite the data of the original file in a more efficient way. Examples of lossless image compression are PNG and GIF.

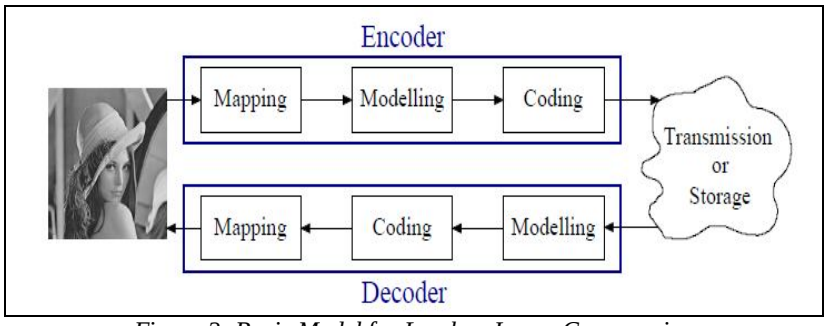

Figure 2: Basic Model for Lossless Image Compression

- Lossless Compression Techniques

1. Run Length Encoding
2. Huffman Encoding
3. Arithmetic Encoding
4. Entropy Coding
5. Area Coding

4.2. Lossy Image Compression

In lossy compression methods, the compression is irreversible the reconstructed data set is only an approximation of the original image. At the cost of lower conformity between reconstructed and original data, better effectiveness of compression can be achieved. A lossy compression method is called visually lossless when the loss of information caused by compression-decompression is invisible to an observer. The most common example of lossy compression is JPEG. The limitation on the effectiveness of lossless compression techniques brought about demand for different approach to compression, which will give better compression ratios. Better effectiveness can be achieved only by disposing of the reversible character of the encoding process. The lossy compression methods reduce the information of the image to be encoded up to some level that is accepted by a particular application field. Lossy compression schemes essentially exploit the psycho visual redundancy.

- Lossy Compression Techniques:

1. Predictive Coding
2. Transform Coding (FT/DCT/Wavelets)

5. Literature Survey

1- In 2011, A. Benjamin Joseph, et al proposed an image compression technique using Wavelet and edge based segmentation. In this method they used Modified Fast Haar wavelet transform (MFHW) and Bit Plane Encoder to elevate the compression ratio and through this method increase PSNR. The Proposed method preserves the quality of the foreground image, but in normal compression algorithms will not preserve the high frequency details such as edges, corners etc., In the proposed method edges are preserved and used for segmenting the layers of the original image. In this the two level fast haar wavelet transform is used to decompose the image at different frequency levels, which has high multi-resolution characteristics. In this work the edge preserved image compression using wavelet and edge based segmentation is implemented using MATLAB with various test images such as Lena, baboon, cameraman etc. The results are computed in terms of Compression ratio and PSNR. The compression ratio of their proposed method is superior to existing method and the quality of the image is also improved than existing method in terms of PSNR. In future the proposed method can be elaborate for color images rather than gray scale image.

2- In 2011, N. Senthilkumaran, et al Present neural network based method for lossless image compression. In this paper authors use improved Backpropagation Neural Network method, for lossless image compression. In this they proved that the improved Backpropagation Neural Network method works better than existing Huffman Coding Technique. In this they system used three parameters such as compression ratio, the transmission time and compression performance to compare and analyze the results with the results of the Huffman Coding Technique.

3- In 2012, A. Alarabeyyat1, et al Proposed combination method for lossless image compression. Their proposed method is a mix of already existing techniques. In the combination method they use two methods such as Lempel-Ziv-Welch (LZW) algorithm on the image in hand; the output of the first step is forward to the second step where the Bose, Chaudhuri and Hoc-quenghem (BCH) algorithm for error correction and detection is used. The proposed method is a lossless image compression scheme which applies to all types of image. For better compression ratio, the proposed method applied the BCH algorithms repeatedly until "inflation" is detected. The results of their proposed method had a better compression ratio than the standard compression technique.

4- In 2012, Mridul Kumar Mathur, et al Present lossless Huffman coding technique for image compression and reconstruction using binary trees. In this technique they have converted an image into an array using Delphi image control tool. An algorithm forms in Delphi to implement Huffman coding method that removes redundant codes present in the image and compressed a BMP image file and it is successfully reconstructed. It can also apply on other kind of RGB images, but it gives some color quality loss after reconstruction. This image compression technique is well suited for grayscale (black and white) bitmap images.This method can be elevated using adaptive Huffman coding technique that is an extension to Huffman coding.

5- In 2014, S. Sridhar, et al Present an evaluation of wavelet transforms techniques for image compression. I this paper authors discuss about the relative merits of different Wavelet transform techniques are evaluated using objective fidelity measures- PSNR and MSE, results. Their Proposed work is carried out by the application of diverse hand designed wavelet families like Haar, Daubechies, Biorthogonal, Coiflets and Symlets etc. on a variety of bench mark images. Haar, Daubechies, Symlets, Coiflets and biorthogonal wavelets are few DWT families discussed in this work. In this work the results obtained clearly indicate that Biorthogonal functions offer good compression performance than remaining ones; however the Daubechies functions do perform better in statistical terms.

6- In 2014, Amita Rakshit, et al introduce A Hybrid JPEG & JPEG 2000 Image Compression Scheme for Gray Images. The goal of compression algorithms is to gain best compression ratio with acceptable visual quality. In this paper, they propose a Hybrid DWTDCT algorithm for image compression and reconstruction taking benefit from the advantages of both algorithms. The simulation results show that the proposed Hybrid DWTDCT algorithm performs much better than standalone JPEG based DCT, and JPEG 2000 based DWT in terms of BPP and CR. In future work they try to improve the quality of the image compared to DCT and DWT using Huffman or arithmetic coding in Hybrid DWT and DCT.

7- In 2014, Neha S. Korde, et al Proposed Wavelet Based Medical Image Compression For Telemedicine Application. In this paper, they discuss about a simple and lossless compression method for compression of medical images. The method is based on wavelet transform of medical application. Wavelets provide a mathematical way of encoding information in such a way that it is layered according to level of detail. A compression of medical imagery is an important area of biomedical and telemedicine. As in telemedicine, videos and the medical images are transmitted through advanced telecommunication links, so the help of medical image compression to compress the data without any loss of useful information. They are using different types of wavelet based compression which has much better coding efficiency and less computational complexity.

8- In 2014, Deepak.S.Thomas1, et al discusses about compression of medical image based on automated ROI selection for telemedicine application. By this work's author proposed a hybrid image compression model for efficient transmission of medical image using lossless and lossy coding of telemedicine applications. In this paper Fast- discrete curvelet transform with adaptive arithmetic coding will be used for lossless compression. This method will be evaluated through parameters like mean square error, quality factor and compression ratio. This project heavily utilized for compressing medical images to transmit for telemedicine application. To minimize the information loss, arithmetic entropy coding was used effectively.
9- In 2014, M. Suganya et al, present Lossless Compression for color medical image and reconstruction. This paper presents colour medical image compression using Curvelet transform with lifting and Huffman coding. It also presents the decompression using inverse transforms and the performance is analyzed using subjective and objective quality metrics. The Curvelet transform is well suited for color medical images which are normally having curvy portions. Various medical images such as MRI, CT, etc. are compressed for different image sizes and the results are analyzed using compression ratio, PSNR, bits per pixel value, mean square error, structural correlation, normalized correlation and average difference. The proposed method gives a higher compression ratio when compared to other compression schemes with perfect post reconstruction quality.
10- In 2012, S.S. Panda et al, proposed back propagation neural network based image compression. In the present research work back propagation neural network training algorithm has been used. Back propagation neural network algorithm helps to increase the performance of the system and to decrease the convergence time for the training of the neural network. The implementation of back propagation neural network algorithm of image compression system with good performance has been demonstrated. The back propagation neural network has been trained and tested for the analysis of different images. The field of image processing has been growing at a very fast pace. The day to day emerging technology requires more and more revolution and evolution in the image processing field. The same experiments should also be conducted with other types of neural network.
11- In 2013, J. Papitha et al, present A Comparative Study on various compression methods on MR images. For transmitting the medical images over the internet and for storing for future use, different compression techniques have been employed. In this paper authors addressed most of the existing DICOM (Digital Imaging and Communications in Medicine) image compression techniques and studied the performance of the respective compression algorithms. The eight different compression algorithms were tested on more than 200 various MR images for the estimation of quality as well as performance of the compression algorithm. In summary, the level dependent threshold (LDT) and set partitioning in hierarchical trees (SPIHT) algorithms are found to be more efficient than the other methods for medical MRI image compression.
12- In 2013, Chiyuan Zhang et al present Image Compression based on learning to minimize the total error. In this paper, they consider the problem of lossy image compression. Recently, machine learning techniques have been introduced as effective mechanisms for image compression. In this paper, they propose a novel algorithm that makes use of all the colors available during the encoding stage. The experimental results demonstrate the effectiveness of their proposed algorithm. In this work, they proposed the TEM algorithm and its improved version TEM-C for image compression. The key advantage over previous methods comes from the maximum exploitation of the full label set at the encoding stage. Experimental results demonstrated the outstanding performance of the proposed methods.

6. Performance Evaluation Parameters

There are many ways to calculate the effectiveness of the compression. The most often used performance evaluation Parameters for this purpose is compression ratio (CR) and peak signal to noise ratio (PSNR).

6.1. PSNR (Peak Signal-To-Noise Ratio)

It is a parameter which can be measured to find out how well an image is reproduced with respect to the reference image. These variables are signal fidelity metrics and do not measure how viewers perceive impairments. Numerical values of these variables for any image tell us about the quality of that image. The measure of peak signal-to-noise ratio (PSNR) is defined as the following formula:

PSNR $= 10log_{10}\left\{\frac{\sum_{i=1}^{N}\sum_{j=1}^{N}(F(i,j))^2}{\sum_{i=1}^{N}\sum_{j=1}^{N}(f(i,j)-F(i,j))^2}\right\}$

6.2.CR (Compression Ratio)

It is a parameter which expresses the ability of the compression method to reduce the amount of disk space needed to store the data. CR is defined as the number of bits of the original image (Borg) per one bit of the compressed image (Bcomp):

Compression Ratio $(CR) = \frac{Original\ Image\ Size}{Compressed\ Image\ Size}$

A compression ratio like 10 (or 10:1) indicates that the original image has 10 information carrying units (e.g. bits) for every 1 unit in the compressed data set.

The compression percentage (CP) serves the same purpose:

Compression Percentage $(CP) = \left(1 - \frac{1}{CR}\right) \times 100\%$

Another measure of the compression effectiveness is the bit rate (BR), which is equal to the average number of bits in compressed representation of the data per element (symbol) to the original set of data. High effectiveness of a compression method manifests itself in high CR and CP, but in low BR. When the time needed for compression is important must be used different factor product of time and bit rate. Here were mentioned only the most commonly used factors, but there are many more ways to estimate the effectiveness.

7. Conclusion

This paper presents various types of methods for image compression. There are basically two types of image compression methods exist. Comparing the performance of compression methods are difficult unless identical data sets and performance measures are used. After study of all techniques it is found that lossless image compression techniques are much better over the lossy compression techniques. Lossy provides a higher compression ratio than lossless. By contrast, lossless compression is needed for text and data files.

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