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The state -of- art Image compression: A Review

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Abstract

The rapid growth of digital technology has paved the way for many image processing applications and motivated the need for better compression algorithms. Image compression is the technique where the size of an image is minimized by keeping the quality of the image to an acceptable level. The main objective of image compression is to decrease the redundancy of the image thereby increasing the capacity of storage and efficient transmission. There are different ways by which images can be compressed. The purpose of this paper is to present information about Image Compression Technique. With a basic concept of image compression, an overview of various compression algorithms is presented here.

Keywords:- Compression, DWT, EZW, SPIHT.

1. INTRODUCTION

Compression turned out to be an essential part of today's digital world. Compression not only minimizes bandwidth and storage requirements but also reduces the time required to transmit information. Consequently, the methods of constricting data prior to storage or transmission are of significant practical and commercial interest most compression schemes are lossy, where high constriction ratios are obtained by sacrificing info within certain allowable degradation limits. Documents preserving, medical and satellite imaging or any application demanding ultra-high image fidelity etc. are the important areas, [1-2] that require lossless compression (i.e., reconstruct the constricted data without any loss of information). The performance of an image compression algorithm can be specified in the term of quality Benchmarking Metrics. Constriction system mainly comprises of two blocks i.e. Encoder and Decoder. Input is fed into encoder which encodes the data to make it suitable for transmission and Decoder receives compressed data and reconstructs the output. If the system is error free, then the output is exact replica of input. Encoder and decoder comprise of three and two blocks respectively. Encoder consists of Mapper, Quantizer and Symbol Encoder. The mapper converts the image into a format arranged to reduce spatial domain redundancies [3] in the input image. Quantizer is generally a lossy process which degrades mapper"s output according to some pre-established criterion. Symbol Encoder generates a variable-length code [4] to present quantizer"s output and drafts the result according to the coding method used. Decoder consists of inverse Mapper and symbol Decoder.

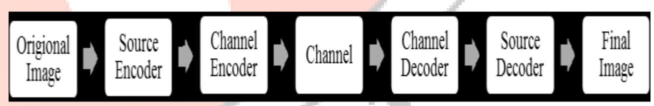

Fig. 1 block diagram

This paper is arranged in the way as Section I presents Introduction, Section II overviews Compression Procedures Section III specifies Lossless Approaches, Section IV convey Lossy Approaches, Section V describes the Comparative analysis of Compression Measures Section VI presents Concluding remarks and Future Scope, and at last References.

2. COMPRESSION PROCEDURES

Image compression aims at reducing the irrelevant and redundant part of the image data in order to store or transmit data in an efficient form. This is achieved through the method of minimizing the number of bits required to represent each pixel in an image. This reduces the memory space required to store images and facilitates transmitting image in less time [5]. The basic flow of image compression is illustrated in Fig 1. The image is given to the encoder which transforms the image into bit streams. When the decoder gets these encoded bit streams it decodes it and the resultant image is obtained from the output of the decoder. Image compression occurs when the overall data quantity of the input image is greater than that of the received bit stream.

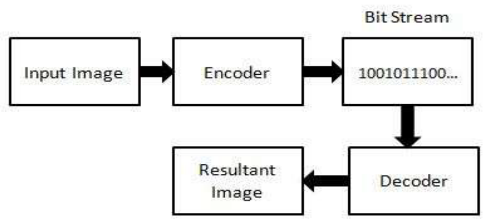

Fig 2 image compression

DATA REDUNDANCY

Digital image compression is a field that studies the techniques for reducing the total number of bits required to represent an image. This can be achieved through the process of eliminating various types of redundancy that exist in the image. In general, there are three basic redundancies in digital images as follows [6].

- Coding Redundancy
- Inter-pixel Redundancy
- Psycho-visual Redundancy

(i) *Coding Redundancy*: Usually the uncompressed image is coded with each pixel by a fixed length code word. For example, an image with 256 gray values is represented by an array of 8-bit integers. By making use of some variable length code schemes such as Huffman coding and arithmetic coding, compression can be achieved, i.e. by assigning less number of bits for more frequent gray levels and more number of bits for less frequent gray levels, then the entire image can be represented by least possible number of bits. In this way we can reduce the coding redundancy.

(ii) *Inter-pixel Redundancy*: It is a redundancy related to statistical dependencies among pixels, especially between neighboring pixels. Information is unnecessarily replicates in the correlated pixels.

(iii) *Psycho-visual Redundancy*: It is a redundancy corresponding to different sensitivities of human eyes to all image signals. Therefore, eliminating some less sensitive information from the image based on our visual processing may be acceptable.

Types of image compression

Image compression techniques are broadly classified into two categories: Lossy and lossless image compression [7-10].

a) Lossless image compression

In lossless compression the original data is perfectly reconstructed from the compressed data. It make use of all the information in the original image while compression, so when the image is decompressed, it will be exactly identical to the original image. Images in which geometric shapes are relatively simple can be considered for lossless image compression. Various techniques include:

- Huffman Encoding
- Run Length Encoding
- Arithmetic Coding
- Entropy Encoding
- Lempel–Ziv–Welch Coding

b) *Lossy Compression Techniques*

In lossy compression the reconstruction of an image is only an approximation of the original data. This suffers from loss of some data. It is most commonly used to compress multimedia data. An advantage of this technique is that it allows for higher compression ratio than the lossless technique. Different methods include:

- Predictive coding
- Transform coding

3. LITERATURE REVIEW

The objective of image compression is to reduce the storage space required to store the digital images. Digital images are used in several fields and sometimes they needed to be compressed for various applications. Image compression techniques are used according to the requirement of application. The objective of compression is to reduce the number of bits as much as possible, while preserving the visual quality of the reconstructed image close to the original image.

In [11], the authors proposed a compression technique using the two lossless methodologies Huffman coding and Lempel Ziv Welch coding to compress image. First the image is compressed with Huffman coding resulting the Huffman tree and Huffman Code words. After that Huffman code words are concatenated together and then compressed by using Lempel Ziv Welch coding. Finally Retinex algorithm is used on compressed image to enhance the contrast of image and improve the quality of image. The amount of compression achieved depends upon the characteristics of the source to a great extent. It was noted that the higher data redundancy helps to achieve more compression. Reproduced image and the original image are equal in quality by using Retinex Algorithm, as it enhances the image contrast using MSR.

In [12], a lossless image compression based on Huffman algorithm is presented. The image is converted into an array using Delphi image control tool. Huffman coding method is used to removes redundant codes from the image and compresses a BMP image file. Huffman coding is a form of coding technique which attempts to reduce the amount of bits required to represent a string of symbols. This image compression scheme is well suited for gray scale (black and white) bit map images. Huffman coding suffers from the fact that the decompressed need to have some knowledge about the probabilities of the symbols in the compressed files. It need more bit to encode the file if this information is unavailable. Huffman coding requires knowledge about the probabilities of the source sequence. If this knowledge is not available, Huffman coding becomes a two-pass operation. In the first pass statistics are collected and in the second pass source is encoded.

In order to transfer this algorithm into a one-pass procedure, adaptive algorithms were developed [13]. This method can be used both for lossy and lossless compression. It provides better compression ratios compared with other lossless coding methods like LZW coding method, JPEG lossless compression. The performance of this method increases by using better predictive methods.

M. Mozammel Hoque Chowdhury suggests an image compression scheme based on discrete wavelet transformation (DWT) [14]. This reduced the redundancy of the image data in order to be able to store or transmit data in an efficient form. It was noted that discrete wavelet transform offers less computational complexity without any sacrifice in image quality. First the image is decomposed into sub-bands and then the resulting coefficients are compared with a threshold. Coefficients below the threshold are taken as zero. Finally, the coefficients above the threshold value are selected and encoded with a loss less compression technique. He also noted that wavelets are well suited to time-limited data and wavelet based image compression technique maintains better image quality with less errors.

Monika Rathee presents discrete Haar wavelet transform (DWT) for image compression [15]. She states that DWT can be used to reduce the image size without losing much of the resolutions. Haar Transform is a very fast transform. Discrete wavelet transform (DWT) represents an image as a sum of wavelet functions on different resolution levels. There exists a large choice of wavelet families depending on the wavelet function. The choice of wavelet family depends on the application. A Haar mother wavelet function and its scaling function has also been described. Compression is done by first digitize the source image into a signal and then decompose the signal into a sequence of wavelet coefficients. A threshold value is used to modify the wavelet coefficients. Quantization is performed to convert a sequence of floating numbers to a sequence of integers. Entropy encoding is applied to change an integer sequence into a shorter sequence with numbers being 8 bit integers. This technique considerably improves the time performance of the system.

Wavelet transform is one of the important methods used for image compression. Information about wavelet image compression technique to fulfill the requirement of image compression that is to reduce data storage capacity or reduce transmission bandwidth was proposed by Rasika N Khatke [16]. The method provides a wavelet transforms technique to generate transform coefficients of an input image. Furthermore, the method generates and encodes an efficient tree structure of the transform coefficients that are obtained. The transform coefficients are quantized based on the quantizing interval to produce quantized transform coefficients. The modified tree list along with the quantized transform coefficients is arithmetically coded. The Wavelet transform analyzes a signal in time and scale. It offers multi-resolution capability and it provides improvements in picture quality at higher compression ratios.

In [17], A. M. Raid presented the use of Wavelet Based Image compression algorithm Embedded Zerotree Wavelet (EZW). It is an effective image compression algorithm. The progressive encoding is a common option for compressing wavelet transformed images, since the details are concentrated on higher sub-bands only. Compact binary maps are provided by significant wavelet coefficients by zero tree coding. The tree maintains a parent-child relationship among the coefficients of sub-bands having the same spatial orientation. These parent-child dependencies contributed excellent performance to the zero-tree coders. It was noted that EZW is fast, robust and efficient enough to implement it in still and complex images with significant image compression. Security can be given to the image along with effective compression.

Ch. Naveen in his paper discussed about the part of EZW in providing additional security to image along with its main function of compression [18]. The process starts by providing image security with compressing the image using EZW. This will generate four different data vectors out of which one is coded sequence. The coded sequences are taken and convert it into2D sequence. On the 2D data chaos based scrambling method is applied using two initial conditions (keys) for row and column respectively. The user must provide same key at the time of descrambling and reconstruction of image. To reconstruct the image using decoding process, the encoded bit stream in the same order as at the time of generation is required. This helps in making the algorithm more robust.

ZHANG Wei noted that an EZW and Huffman joint encoding algorithm can reduce the desired number of digits used for coding [19]. The average code length will be shorter due to the repetition of the output stream, if joint Huffman coding is done on the output stream which can improve the compression ratio. Huffman encoding is a lossless coding method. It does not affect the image recovery theoretically. By this joint technique of EZW with Huffman coding scheme provides a method with better compression ratio and coding efficiency.

Set partitioning in hierarchical trees (SPIHT) is wavelet based algorithm which is computationally very fast and offers good compression ratio [20, 21]. It is an extension of embedded zero tree wavelet (EZW) coding method. It is based on spatial orientation trees and makes use of set partitioning sorting algorithm. SPIHT defines parent-children relationships between similar sub bands to establish spatial orientation trees. The SPIHT algorithm encodes the image file using three lists such as LIP, LIS and LSP. LIP list contains the individual coefficients that have magnitudes smaller than the threshold values. LIS list contains the overall wavelet coefficients that are defined in tree structure with magnitudes smaller than the threshold values. LSP is the set of pixels having magnitude greater than the threshold value. Sorting process and refinement process is carried out to select the coefficients that are important. Precise rate control is an important characteristic of SPIHT algorithm.

In [22], an image compression using Modified Set Partitioning in Hierarchical Tree (M-SPIHT) algorithm has been presented. In SPIHT, the usage of three temporary lists is an efficient way to improve the coding efficiency. But they are quite memory consuming. It is a major drawback for SPIHT algorithm. The elements are often inserted or deleted in the lists during coding. These frequent operations will increase the coding time with the expanding of the lists. In M-SPIHT, the sorting and refinement phase are combined as one pass. The sorting and refinement pass are combined together to reduce the execution time. M-SPIHT provides an essential algorithm for image compression and makes the zero tree-based encoders more competitive than other wavelet encoders. This algorithm can be used for medical signal compression to coding-decoding for mobile communication because of having good PSNR at very low bit rate.

In [23], Sure Srikanth carried out a comparative study of different embedded Wavelet based image coding like EZW, SPIHT and Modified SPIHT algorithms in combination with Huffman encoder. EZW algorithm is a progressive encoding scheme used to compress an image into a bit stream with an increase in accuracy. SPIHT is an efficient image compression algorithm that codes groups of wavelet coefficients as zero trees. Modified SPIHT algorithm provides significant quality reconstruction at the decoder without any additional computational complexity. Unlike ASCII code, which is fixed-length code, Huffman coding is a variable length code system that assigns smaller code word for more frequently used characters and larger code word for less frequently used characters in order to reduce the size of files being compressed.

Modified SPIHT encodes the sub band pixels by performing initialization and a sequence of sorting pass, refinement pass and quantization-step updating. These hybrid algorithms yield quite promising PSNR values at low bitrates.

Charles D. Creusere proposed a wavelet-based image compression algorithm that achieves robustness to transmission errors by partitioning the transform coefficients into groups [24]. These groups are independently processed using an embedded coder. Thus, a bit error in one group does not affect the others, allowing more information to reach the decoder correctly. The basic idea of this robust EZW image compression algorithm is to divide the wavelet coefficients into S groups. Quantization and coding is done on each of them independently so that S different embedded bit streams are created. By coding the wavelet coefficients with independent bit streams, a single bit error truncates only on one of the streams, the others are still completely received. Thus robustness to transmission errors is added to an embedded image compression algorithm without any definable increase in its complexity.

In [25], the authors discussed about the problems that arise due to the normal EZW method. The main issue in the EZW is that a single bit error in the string can lead to the entire bit stream to reconstruct incorrectly. The bits those are decoded after the error bit becomes useless for reconstruction of the image. Thus, it affects reconstruction quality of the whole image. To overcome this problem the authors proposed a block based EZW. The advantage of this method is that one single bit error in the bit stream only affects the reconstruction quality of that particular block. Other blocks can be reconstructed without any problem.

An improvement or modification to the block based EZW was proposed by Ch. Naveen [26]. The modifications suggested further improve the compression ratio. The proposed method forces the maximum value in each block to the lowest maximum value of all the blocks in the image. At the encoder, first all the blocks are scaled down to the same maximum value and then it is encoded using EZW technique. To reconstruct the original image, the scaled down values of all the blocks are scaled up to the original maximum values at the receiver. Thus the number of passes applied on each block will be equal to the lowest number of passes taken by one of the blocks in image. This downside approach will reduce the number of bits used for encoding the image which successively increase the compression ratio.

4. CONCLUSION AND FUTURE SCOPE

Image compression is very important for efficient transmission and storage of images. The work in this paper primarily focuses at comparing the most widely used techniques in the image compression domain on various images. The techniques are successfully studied and implemented on various images. The compression algorithms are implemented using the MATLAB 2016a software on different test images. According to the result calculated in table 1 JPEG gave higher compression but quality was not maintained up to the mark whereas PNG has maintained high quality but gave low compression rate. Every compression is best in its own dimensions. In the near future, more compression Techniques will be considered which can compress with higher compression ratio and maintain the quality of image. In future, many technologies can arise in which compression can be done not only on the basis of redundancy but on symmetry in the images too.

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