An Extensive Review on Color Image Compression Methods

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Abstract- Images have been with us since the dawn of time. However, the way that image have been represented and displayed has changed greatly. Originally every image was unique, being both represented and displayed in a physical way, such as paint on a cave wall or etchings in stone. However, in recent times images have been dealt digitally. One consequence of this is that the representation used for transmission or storage of the image can be separated from the means of display. By storing images in digital form, the possibilities for image representation increase dramatically. 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. This examination reported an extensive survey of literature on color image compression approaches.

Keywords- Image Compression, Image Decompression, Lossy Compression, Loss less Compression, Data Compression, Compression ratio, DCT, DWT, PSNR, MSE, Wavelet, Transform

I. INTRODUCTION

Compression is a transformation of original data representation into different representation characterized by smaller number of bits. Opposite process – reconstruction of the original data set is called decompression.

There can be distinguished two types of compression: lossless and lossy. In lossless compression methods, the data set reconstructed during decompression is identical as the original data set. In lossy 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 for an observer (during presentation of image in normal conditions). However, the assessment, if a compression of an image is visually lossless, is highly subjective. Besides that, the visual difference between the original and decompressed images can become visible when observation circumstances change. In addition, the processing of the image, like image analysis, noise elimination, may reveal that the compression actually was not lossless.

A real image can be characterized as a continuous two-dimensional (2D) function f(x; y). To become a digital image, this function must be digitized. This is achieved by measuring the value of the function at axed number of locations (spatial sampling) and limiting the result to axed set of values (amplitude quantization). The relationship between pixels values and an image is illustrated in Figure 1.1.

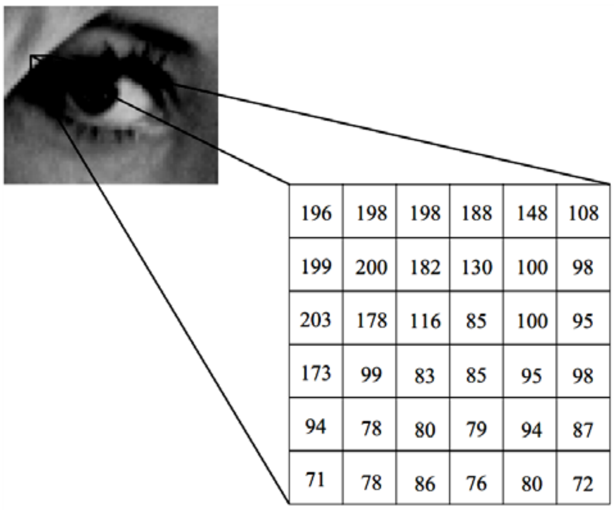

Fig. 1.1 Alternative view of image data.

The number of samples taken determines the resolution of the image. For example, using a rectangular grid of equally spaced sampling points, with 1024 sampling points per row and 768 per column, yields an image with a resolution that is written 1024 768. Each sample is generally thought of as representing the intensity of a picture element or pixel.

The size of the set of values that can be taken by a pixel is almost always a power of n_2. If a pixel can have 2 values, then it requires n bits of storage. Thus, a two-tone image (e.g. a fax) would have a binary value for each pixel, and is often referred to as a 1 bit image. Continuous-tone greyscale images generally use 8 bits per pixel (bpp) and colour images use 24 bits per pixel (8 each for red, green and blue). Medical and scienti c images typically use more bits per pixel, sometimes up to 16 bpp for greyscale.

Taken together, the values of all the pixels in an image constitute the raw data representation of the image. The amount of storage required by this raw data can be calculated as the product of the number of pixels and the bits used per pixel.

II. FUNDAMENTALS OF IMAGE COMPRESSION

The term data compression refers to the process of reducing the amount of data required to represent a given quantity of information. A common characteristic of most images is that the neighboring 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. Redundancy reduction aims at removing duplication from the signal source (image/video). Irrelevancy reduction omits parts of the signal that will not be noticed by the signal receiver, namely the Human Visual System (HVS).

It is not an abstract concept but a mathematically quantifiable entity. If n_1 and n_2 denote the number of information-carrying units in the two data sets that represent the same information, the relative data redundancy RD of the first data set (the one characterized by n_1)can be defined as

$$RD = 1 - \frac{1}{CR} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots..(1)$$

Where CR , commonly called the compression ratio, is

$$CR = \frac{n_1}{n_2}, \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

For the case $n_2 = n_1$ and RD = 0, indicating that (relative to the second data set) the first representation of the information contains no redundant data. When $n_2 \ll n_1$. CR $\to \infty$ and RD ->1,implying significant compression and highly redundant data. When $n_2 \gg n_1$, CR ->0and RD -> $-\infty$,indicating that the second data set contains much more data than the original representation. Generally CR =10(10:1) defines that the first data set has 10 information carrying units for every 1 unit in the second or compressed data set. Thus the corresponding redundancy of 0.9 means 90 percent of the data in the first data set is redundant with respect to the second one.

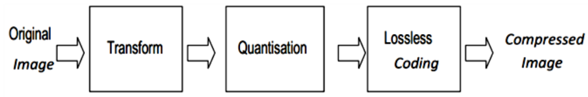

Fig. 2.1 Image compression system.

The problem faced by image compression is very easy to define, as demonstrated in figure 2.1. First the original digital image is usually transformed into another domain, where it is highly de-correlated by using some transform. This de- correlation concentrates the important image information into a more compact form. The compressor then removes the redundancy in the transformed image and stores it into a compressed file or data stream. In the second stage, the quantisation block reduces the accuracy of the transformed output in accordance with some pre- established fidelity criterion.

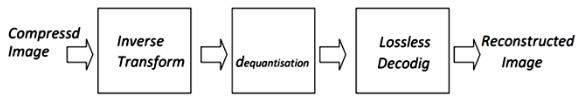

Fig. 2.2 Image decompression system.

The decompression reverses the compression process to produce the recovered image as shown in figure 2.2. The recovered image may have lost some information due to the compression, and may have an error or distortion compared to the original image.

III. LITERATURE REVIEW

SR. No.	TITLE	AUTHOR	YEAR	APPROACH
1	Cross-Space Distortion Directed Color Image Compression	S. Zhu, M. Li, C. Chen, S. Liu and B. Zeng,	2018	A novel compression scheme for color images through defining a cross-space distortion so as to reduce as much as possible the distortion in the RGB space
2	Low-cost color space based image compression algorithm for capsule endoscopy	N. V. Malathkar and S. K. Soni	2017	A simplified YUV color space, which is developed by taking endoscopy images unique properties into consideration

3	An efficient framework for lossless color image compression	Z. Luo and Y. Wan	2016	Propose an efficient lossless color image compression framework.
4	Comparative analysis of lossless compression techniques in efficient DCT-based image compression system based on Laplacian Transparent Composite Model and An Innovative Lossless Compression Method for Discrete-Color Images	T. K. Poolakkachalil, S. Chandran, R. Muralidharan and K. Vijayalakshmi	2016	A comparison between two latest works in the image compression An Efficient DCT-Based Image Compression System Based on Laplacian Transparent Composite Model and An Innovative Lossless Compression Method for Discrete-Color Images
5	A new model for color image compression using modified hierarchical prediction	S. Sathappan and P. S. Babu	2015	Utilized new lossless color image compression algorithm based on the hierarchical prediction and context-adaptive arithmetic coding.
6	An Innovative Lossless Compression Method for Discrete-Color Images	S. Alzahir and A. Borici	2015	Present an innovative method for lossless compression of discrete-color images, such as map images, graphics, GIS, as well as binary images
7	An Approach for Color Image Compression of JPEG and PNG Images Using DCT and DWT	A. H. M. J. I. Barbhuiya, T. A. Laskar and K. Hemachandran	2014	A comparative study has been carried out on image compression using DCT (Discrete Cosine Transform) and DWT (Discrete Wavelet Transform).

S. Zhu, M. Li, C. Chen, S. Liu and B. Zeng [1] Traditional color image compression is usually conducted in the YCbCr space but many color displayers only accept RGB signals as inputs. Due to the use of a non-unitary matrix in the YCbCr-RGB conversion, low distortion achieved in the YCbCr space cannot guarantee low distortion for the RGB signals. To solve this problem, a novel compression scheme for color images through defining a cross-space distortion so as to reduce as much as possible the distortion in the RGB space has proposed. To this end, first derive the relationship between the distortions in the YCbCr space and RGB space. Then, develop two solutions to implement color image compression for the most popular 4:2:0 chroma format. The first solution focuses on the design of a new spatial downsampling method to generate the 4:2:0 YCbCr image for a high-efficiency compression. The second one provides a novel way to reduce the distortion of the compressed color image by controlling the quantization error of the 4:2:0 YCbCr images, especially the one generated by using the traditional spatial downsampling. Experimental results show that both proposed solutions offer a remarkable quality gain over some state-of-the-art approaches when tested on various textured color images.

N. V. Malathkar and S. K. Soni, [2] An efficient compression algorithm for the capsule endoscopy is described in this exploration. This examination work consists of a simplified YUV color space, which is developed by taking endoscopy images unique properties into consideration. This is built on RGB-sYUV color conversion, differential pulse code modulation (DPCM) and Golomb-Rice encoder. This DPCM doesn't need any extra buffer memory to store one row of images and Golomb-Rice (G-R) code is simple and easily hardware implemented. This algorithm is lossless and gives a compression ratio (CR) of 68.1%. It gives better results than the standard lossless algorithm regarding complexity and compression ratio in capsule endoscopy applications.

Z. Luo and Y. Wan [3] There are many methods for compressing color images nowadays and most of them are lossy. However, in many important situations, lossless color image compression is irreplaceable. In this work, an efficient lossless color image compression framework has proposed. In this framework, for an RGB image, it is first decorrelated via a reversible color transform. In the new color space, the color components are directly down sampled and then interpolated to the original size. Next subtract these interpolated components from their original counterparts to obtain the prediction errors, which together with the color subcomponents are compressed via Huffman coding. At the decoder, the exact reverse process is used to reconstruct the original color images. Experimental results show that the proposed method achieves overall better compression performance compared with the famous CALIC algorithm and some other popular methods used in the TIFF and PNG color image compression standards.

T. K. Poolakkachalil, S. Chandran, R. Muralidharan and K. Vijayalakshmi [4] The main objective of image compression is to diminish the number of bits required to represent an image by eliminating the spatial and spectral redundancies. Image compression is classified as lossy and lossless compression. Lossy compression reduces the size of a file by removing redundant information. Whereas, in the lossless compression there won't be any loss of information upon the extraction of original image from the compressed image. The aim of this examination is to do a comparison between two latest works in the image compression namely, An Efficient DCT-Based Image Compression System Based on Laplacian Transparent Composite Model and An Innovative Lossless Compression Method for Discrete-Color Images. From the analysis, it is observed that on average, An Efficient DCT-Based Image Compression System Based on Laplacian Transparent Composite Model reduces the compression rate by 25% in the case of images, compared to JBIG2. It is also observed that this approach is better suited for traditional images like Lena and Goldhill while An Innovative Lossless Compression Method for Discrete-Color Images is better suited for charts and maps.

S. Sathappan and P. S. Babu [5] In today's life, images play a significant role in many application fields for numerous purposes. Image processing has to face the huge challenges because of images created in digital format which leads to huge data volumes. In recent days, to meet the diverse type of real time applications, the Joint Photographic Experts Group (JPEG) compression techniques are used, which are used to minimize the expenditure of possessions such as hard disk space and transmission bandwidth. Preceding examination utilized new lossless color image compression algorithm based on the hierarchical prediction and context-adaptive arithmetic coding. In this work the specified image is transformed into YCuCv color space by RCT (Reversible Color Transform) coordination by using lossless compression technique and image compression is acquired. Preserving the sharpness of the original image is a prominent factor in image compression. New schemes are required in preserving the sharpness and reduction in bitrates in the further progress. Proposed work recommended the approach which reduces the bitrates more than 1. The proposed scheme is named as Modified Hierarchical Prediction which removes the enormous prediction error rate near edges and preserves the sharpness of images. This examination considers the vertical, horizontal and diagonal (left up, left down and right up, right down) predictors to predict pixels. Diagonal predictor enhances the perdition accuracy of pixels in Hierarchical Prediction. The experimental result shows that the proposed Modified Hierarchical Prediction based scheme preserve the sharpness of the image.

S. Alzahir and A. Borici [6] In this work, an innovative method for lossless compression of discrete-color images has present, such as map images, graphics, GIS, as well as binary images. This method comprises two main components. The first is a fixed-size codebook encompassing 8×8 bit blocks of two-tone data along with their corresponding Huffman codes and their relative probabilities of occurrence. The probabilities were obtained from a very large set of discrete color images which are also used for arithmetic coding. The second component is the row-column reduction coding, which will encode those blocks that are not in the codebook. The proposed method has been successfully applied on two major image categories: 1) images with a predetermined number of discrete colors, such as digital maps, graphs, and GIS images and 2) binary images. The results show that our method compresses images from both categories (discrete color and binary images) with 90% in most case and higher than the JBIG-2 by 5%-20% for binary images, and by 2%-6.3% for discrete color images on average.

A. H. M. J. I. Barbhuiya, T. A. Laskar and K. Hemachandran [7] Now a days image compression has become is an indispensible part of digitized image storage and transmission. Compression of an image is necessary before storing and transmitting it due to its limitation of storage and bandwidth capacity. Wavelet transform decomposes complexion of images into its elementary forms. In this work, a comparative study has been carried out on image compression using DCT (Discrete Cosine Transform) and DWT (Discrete Wavelet Transform). A comparison is outlined to emphasize the results of this compression system between DCT and DWT using JPEG (Joint Photographic Experts Group) and PNG (Portable Network Graphics) color images. A conversion of color images into gray scale and also compression of gray scale image is shown after conversion using DWT method has done in this work. DWT algorithm performs much better than DCT algorithms in terms of Compression, Mean Square Error (MSE) and Peak Signal to Noise Ratio (PNSR).

IV. PROBLEM IDENTIFICATION

Image Compression addresses the problem of reducing the amount of data required to represent the digital image. Compression is achieved by the removal of one or more of three basic data redundancies: (1) Coding redundancy, which is present when less than optimal (i.e. the smallest length) code words are used; (2) Intermixed redundancy, which results from correlations between the pixels of an image; &/or (3) psycho visual redundancy which is due to data that is ignored by the human visual system (i.e. visually nonessential information). In order to be useful, a compression algorithm has a corresponding decompression algorithm that reproduces the original file once the compressed file is given. There are also many situations where loss may be either unnoticeable or acceptable. In image compression, for example, the exact reconstructed value of each sample of the image.

Image compression addresses the problem of reducing the amount of data required to represent a digital image .The underlying basis of the reduction process is the removal of redundant data. From a mathematical viewpoint, this amount to transforming a 2-D pixel array into a statistically uncorrelated data set .The transformation is applied prior to storage or transmission of the image. At some later time, the compressed image is decompressed to reconstruct the original image or approximation of it

V. CONCLUSION

This work presented a survey of literature on color image compression. Uncompressed multimedia (graphics, image) data requires considerable storage capacity and transmission bandwidth. Despite rapid progress in mass-storage density, processor speeds, and digital communication system performance, demand for data storage capacity and data-transmission bandwidth continues to outstrip the capabilities of available technologies. The recent growth of data intensive multimedia-based web applications have not only sustained the need for more efficient ways to encode signals and images but have made compression of such signals central to storage and communication technology. Image Compression addresses the problem of reducing the amount of data required to represent the digital image. Compression is achieved by the removal of one or more of three basic data redundancies discussed in this exploration and analysis.

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