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Color Image Compression using Different Lossy Compression Technique: A Survey

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ABSTRACT: In the present era of multimedia, the requirement of image/video storage and transmission for video conferencing, image and video retrieval, video playback, etc. are increasing exponentially. As a result, the need for better compression technology is always in demand. Modern applications, in addition to high compression ratio, also demand for efficient encoding and decoding processes, so that computational constraint of many real-time applications is satisfied. Three widely used lossy compression techniques are discrete wavelet transform, discrete cosine transform and multi-level block truncation coding (BTC). DCT method is used to stationary images, DWT method is used to stationary and non-stationary images and applied to all average pixel value of image. Multi-level BTC is a type of lossy image compression technique for greyscale images. It divides the original images into blocks and then uses a quantizer to reduce the number of grey levels in each block whilst maintaining the same mean and standard deviation. In this paper is studied of DCT, Multi-level BTC and DWT technique for for gray and color image.

KEYWORDS: Discrete Wavelet Transform, Multi-level, Block Truncation Code (BTC), Discrete Cosine Transform, PSNR MSE, Compression Ratio

I. INTRODUCTION

The use of digital images has increased at a rapid pace over the past decade. Photographs, printed text, and other hard copy media are now routinely converted into digital form, and the direct acquisition of digital images is becoming more common as sensors and associated electronics of very high quality are becoming available now. Many recent imaging modalities in medicine, such as magnetic resonance imaging (MRI) and computer tomography (CT), also generate images directly in digital form. Computer generated (Synthetic) images are becoming an additional source of digital data, particularly for special effects in advertising and entertainment. The reason for this interest in digital images is clear. Representing images in digital form allows visual information to be easily manipulated in useful and novel ways. The amount of data associated with visual information is so large that its storage would require enormous storage capacity. Although the capacities of several storage media are substantial, their access speeds are usually inversely proportional to their capacity. Typical television images generate data rates exceeding 10 million bytes per second. There are other image sources that generate data at even higher rates. Storage and/or transmission of such data require large capacity and/or bandwidth, which could be expensive. Since a considerable degree of redundancy is present in the images and in many cases an image perceptually equivalent but not identical to the original image is acceptable, a decrease in the size of the digital representation by more than an order of magnitude is possible by employing suitable image compression techniques. Image compression reduces redundancy in image data in order to store or transmit only a minimal number of samples from which a good approximation of the original image can be reconstructed in accordance with human visual perception. Many compression methods have been developed. Among them transform coding, multiresolution coding, vector quantization, predictive methods, and other more recent schemes such as fractal image coding and wavelet image coding are important. The proposed work focuses on fractal image compression, lossless image compression using wavelets and image dependent fractal image compression methods.

II. LITERATURE SURVEY

Poonlap Lamsrichan et al. (2021), a new color image compression based on block truncation coding is proposed. After integer color transformation, the new method for encoding all 4 RVs in the 4-level BTC effectively is applied to Y component. The chromatic components are down-sampled and encoded with 2-level BTC. By simple level adjustment,



the encoder and decoder know the number of levels in each block. A variable-length bitmap adjusts to the current level number and raises the compression ratio. With true means as RVs without approximation, the new BTC coder can reach 1~2 dB higher PSNR than some BTC-based coders in the literature.

Haichuan Ma Dong et al. (2020), built on deep networks, end-to-end optimized image compression has made impressive progress in the past few years. Previous studies usually adopt a compressive auto-encoder, where the encoder part first converts image into latent features, and then quantizes the features before encoding them into bits. Both the conversion and the quantization incur information loss, resulting in a difficulty to optimally achieve arbitrary compression ratio. We propose iWave++ as a new end-to-end optimized image compression scheme, in which iWave, a trained wavelet-like transform, converts images into coefficients without any information loss. Then the coefficients are optionally quantized and encoded into bits. Different from the previous schemes, iWave++ is versatile: a single model supports both lossless and lossy compression, and also achieves arbitrary compression ratio by simply adjusting the quantization scale. iWave++ also features a carefully designed entropy coding engine to encode the coefficients progressively, and a de-quantization module for lossy compression. Experimental results show that lossy iWave++ achieves state-of-the-art compression efficiency compared with deep network-based methods; on the Kodak dataset, lossy iWave++ leads to 17.34 percent bits saving over BPG; lossless iWave++ achieves comparable or better performance than FLIF. Our code and models are available at <https://github.com/mahaichuan/Versatile-Image-Compression>.

Fabian Mentzer George et al. (2020), have extensively study how to combine Generative Adversarial Networks and learned compression to obtain a state-of-the-art generative lossy compression system. In particular, we investigate normalization layers, generator and discriminator architectures, training strategies, as well as perceptual losses. In contrast to previous work, i) we obtain visually pleasing reconstructions that are perceptually similar to the input, ii) we operate in a broad range of bitrates, and iii) our approach can be applied to high-resolution images. We bridge the gap between rate-distortion-perception theory and practice by evaluating our approach both quantitatively with various perceptual metrics, and with a user study. The study shows that our method is preferred to previous approaches even if they use more than 2x the bitrate.

H. H. Cheng (2019), a new color image compression algorithm based on Absolute Moment Block Truncation Coding (AMBTC) and entropy coding is proposed. The AMBTC improves the compression performance of Block Truncation Coding (BTC) obviously. A novel technique by using eight different types of bitmap tables is developed for the proposed algorithm. In addition, an entropy coding technique combining prediction and Huffman Coding approach is included in the proposed algorithm and decreased the data amount of luminance images. The experimental results show that more than 82% data amount can be compressed by using the eight different types of novel bitmap tables. Compared with previous studies, this work has better compression performance than previous 4*4 BTC, JPEG, and JPEG-LS algorithms.

C. A. Chen et al. (2019), have presents a hardware-oriented lossless color filter array (CFA) image compression algorithm for very-large-scale integration (VLSI) circuit design. In order to achieve high performance, low complexity and low memory requirement, a novel lossless CFA image compression algorithm based on JPEG-LS is proposed for the VLSI implementation. A previous study showed the usage of a context table with its memory consuming more than 81% of the chip area for a JPEG-LS encoder design. The proposed algorithm implements a JPEG-LS-based lossless image compression algorithm that eliminates the use of the context technique and its memory in order to reduce the chip area while still maintaining its high performance. The proposed algorithm includes a pixel restoration, an adaptive Golomb-Rice parameter prediction and an improved Golomb-Rice coding technique. This paper was realized using a 0.18 μ m CMOS process with synthesized gate counts and core area of 4.8 k and 57,625 μ m², respectively. The synthesized operating frequency of this design reached 200 MHz by using a pipeline scheduling technique. Compared with the previous JPEG-LS-based designs, this paper reduced the gate count to at least 28% and increased the average compression ratio by over 17.15% using the video endoscopy images from the Gastro Gastroenterologist Hospital.

Emiel Hoogeboom et al. (2019), lossless compression methods shorten the expected representation size of data without loss of information, using a statistical model. Flow-based models are attractive in this setting because they admit exact likelihood optimization, which is equivalent to minimizing the expected number of bits per message. However, conventional flows assume continuous data, which may lead to reconstruction errors when quantized for compression. For that reason, we introduce a flow-based generative model for ordinal discrete data called Integer Discrete Flow



(IDF): a bijective integer map that can learn rich transformations on high-dimensional data. As building blocks for IDFs, we introduce a flexible transformation layer called integer discrete coupling. Our experiments show that IDFs are competitive with other flow-based generative models. Furthermore, we demonstrate that IDF based compression achieves state-of-the-art lossless compression rates on CIFAR10, ImageNet32, and ImageNet64. To the best of our knowledge, this is the first lossless compression method that uses invertible neural networks.

Shuyuan Zhu et al. (2018), transform domain downward conversion (TDDC) for image coding is usually implemented by discarding some high-frequency components from each transformed block. As a result, a block of fewer coefficients is formed and a lower compression cost is achieved due to the coding of only a few low-frequency coefficients. In this paper, we focus on the design of a new TDDC-based coding method by using our proposed interpolation-compression directed filtering (ICDF) and error-compensated scalar quantization (ECSQ), leading to the compression-dependent TDDC (CDTDDC) based coding. More specifically, ICDF is first used to convert each 16×16 macroblock into an 8×8 coefficient block. Then, this coefficient block is compressed with ECSQ, resulting in a smaller compression distortion for those pixels that locate at some specific positions of a macro-block. We select these positions according to the 4:1 uniform sub-sampling lattice and use the pixels locating at them to reconstruct the whole macro-block through an interpolation. The proposed CDTDDC-based coding can be applied to compress both grayscale and color images. More importantly, when it is used in the color image compression, it offers not only a new solution to reduce the data-size of chrominance components but also a higher compression efficiency. Experimental results demonstrate that applying our proposed CDTDDC-based coding to compress still images can achieve a significant quality gain over the existing compression methods.

Shih-Lun Chen et al. (2018), color and multispectral image compression using Enhance block truncation code is proposed [1]. These techniques are based on standard deviation and mean. This technique is applied to satellite image and reshapes the satellite image. The satellite image is divided into various sub-blocks. After calculate mean values, all number of pixel in sub-block are compared to the mean and according to the mean all pixel value is replaced by binary number. Finally MSE, PSNR and compression ratio are calculated for the Enhance block truncation code for satellite image.

Jooyoung Lee Seunghyun et al. (2018), with the continuing growth of modern communication technologies, demand for image data compression is increasing rapidly. Techniques for achieving data compression can be divided into two basic approaches: spatial coding and Transform coding. This research paper presents a proposed method for the compression of digital images using hybrid compression method based on Block Truncation Coding (BTC) and Walsh Hadamard Transform (WHT). The objective of this hybrid approach is to achieve higher compression ratio by applying BTC and WHT. Several grayscale test images are used to evaluate the coding efficiency and performance of the hybrid method and compared with the BTC and WHT respectively. It is generally shown that the proposed method gives better results. Processing dependency in the conventional algorithm is removed by partitioning the input image and modifying neighboring reference pixel configuration. Experimental results show that the parallel implementation drastically reduce processing time by 6~7 times with significant visual quality improvement.

Mu Li Wangmeng et al. (2018), image compression plays vital role in saving memory storage space and saving time while transmission images over network. The color and multispectral image is considered as input image for the image compression. The proposed technique with Enhanced Block Truncation Coding [EBTC] is applied on component of color and multispectral image. The component image is divided into various sub blocks. After evaluating mean values, the number of bits can be reduced by Enhanced Block Truncation Coding. Finally, compression ratio table is generated using the parameters such as MSE, SNR and PSNR. The proposed method is implemented through standard color and multispectral images using MATLAB Version 8.1 R2013a.

Julio Cesar Stacchini de Souza et al. (2014), Block truncation committal to writing (BTC) has been thought of extremely economical compression technique for many years. Moreover, this method can provide excellent processing efficiency by exploiting the nature parallelism advantage of the dot diffusion, and excellent image quality can also be offered through co-optimizing the class matrix and diffused matrix of the dot diffusion. According to the experimental results, the proposed DDBTC is superior to the former error-diffused BTC in terms of various objective image quality assessment methods as well as processing efficiency. A modified Block Truncation Coding using max-min quantizer (MBTC) is proposed in this paper to overcome the above mentioned drawbacks. In the conventional BTC, quantization is done based on the mean and standard deviation of the pixel values in each block. In the proposed method, instead of



using the mean and standard deviation, an average value of the maximum, minimum and mean of the blocks of pixels is taken as the threshold for quantization.

III. METHODOLOGY

Coupling ICDF and ECSQ together, we build up the compression-dependent TDDC (CDTDDC) for the compression of image signals and the framework of this coding scheme is shown in Fig. 1. Moreover, when the proposed CDTDDC based coding is adopted in the compression of grayscale images, it will work competitively with the JPEG baseline coding as two coding modes for each macro-block. On the other hand, when it is used to compress color images, it is only performed on two chrominance components after the RGB to- YCbCr conversion. In this way, it offers not only a new solution to reduce the data-size of color images but also a high compression efficiency.

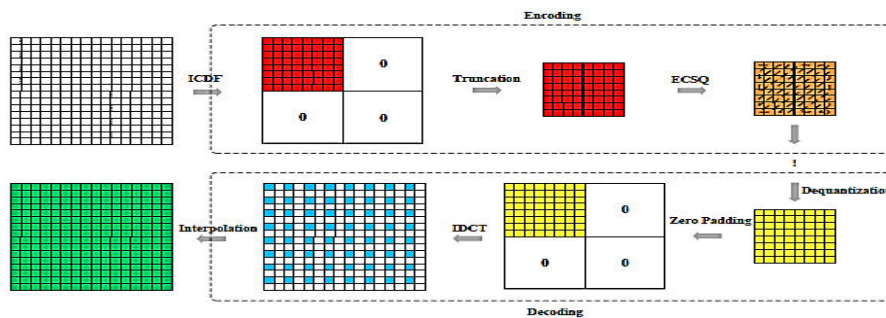


Figure 1: Previous Design

- **Discrete Wavelet Transform**

Wavelets are signals which are local in time and scale and generally have an irregular shape. A wavelet is a waveform of effectively limited duration that has an average value of zero. The term ‘wavelet’ comes from the fact that they integrate to zero; they wave up and down across the axis. Many wavelets also display a property ideal for compact signal representation: orthogonality. This property ensures that data is not over represented. A signal can be decomposed into many shifted and scaled representations of the original mother wavelet. A wavelet transform can be used to decompose a signal into component wavelets. Once this is done the coefficients of the wavelets can be decimated to remove some of the details. Wavelets have the great advantage of being able to separate the fine details in a signal. Very small wavelets can be used to isolate very fine details in a signal, while very large wavelets can identify coarse details. In addition, there are many different wavelets to choose from. Various types of wavelets are: Morlet, Daubechies, etc. [6].

This technique first decomposes an image into coefficients called sub-bands and then the resulting coefficients are compared with a threshold. Coefficients below the threshold are set to zero. Finally, the coefficients above the threshold value are encoded with a loss less compression technique. The compression features of a given wavelet basis are primarily linked to the relative scarceness of the wavelet domain representation for the signal. The notion behind compression is based on the concept that the regular signal component can be accurately approximated using the following elements: a small number of approximation coefficients (at a suitably chosen level) and some of the detail coefficients.

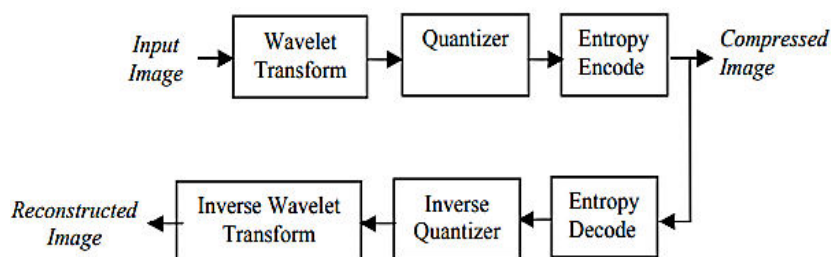


Figure 2: The structure of the wavelet transform based compression.

The steps of compression algorithm based on DWT are described below:

- I. Decompose Choose a wavelet; choose a level N. Compute the wavelet. Decompose the signals at level N.



- II. Threshold detail coefficients For each level from 1 to N, a threshold is selected and hard thresholding is applied to the detail coefficients.
- III. Reconstruct Compute wavelet reconstruction using the original approximation coefficients of level N and the modified detail coefficients of levels from 1 to N.

• **Multi-level Block Truncation Code**

The Encoder and decoder block of the multi-level block truncation code algorithm is shown if figure 2. Encoder part of the proposed algorithm shows that the original image is divided into three parts i.e. R component, G component and B component. Each R, G, B component of the image is divided into non overlapping block of equal size and threshold value for each block size is being calculated.

Threshold value means the average of the maximum value (max) of ‘k × k’ pixels block, minimum value (min) of ‘k × k’ pixels block and m_1 is the mean value of ‘k × k’ pixels block. Where k represents block size of the color image. So threshold value is:

$$(1) \quad T = \frac{\max + \min + m_1}{3}$$

Each threshold value is passing through the quantization block. Quantization is the process of mapping a set of input fractional values to a whole number. Suppose the fractional value is less than 0.5, then the quantization is replaced by previous whole number and if the fractional value is greater than 0.5, then the quantization is replaced by next whole number.

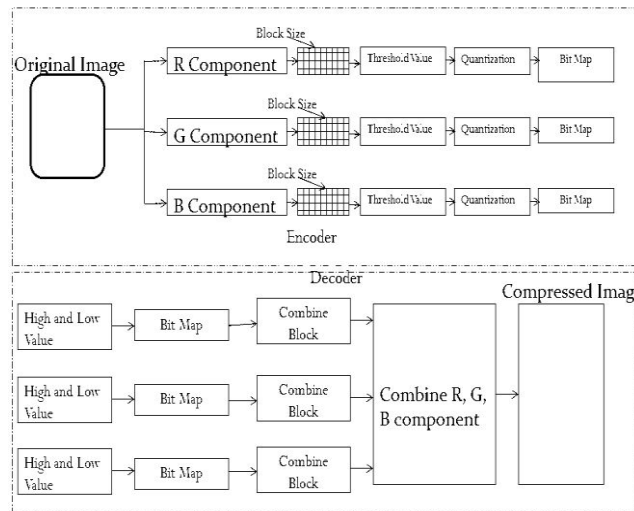


Figure 3: Block Diagram of Proposed Algorithm

Each quantization value is passing through the bit map block. Bit map means each block is represented by ‘0’ and ‘1’ bit map. If the Threshold value is less than or equal to the input image value then the pixel value of the image is represent by ‘0’ and if the threshold value is greater than the input image value then the pixel value of the image is represented by ‘1’.

Bit map is directly connected to the high and low component of the proposed decoder multi-level BTC algorithm. High (H) and low (L) component is directly connected to the bit map, bitmap converted the ‘1’ and ‘0’ pixel value to high and low pixel value and arrange the entire block.

$$(2) \quad L = \frac{1}{q} \sum_{i=1}^p W_i \quad W_i \leq T$$

$$(3) \quad H = \frac{1}{p} \sum_{i=1}^p W_i \quad W_i > T$$



W_i represent the input color image block, q is the number of zeros in the bit plane, p is the number of ones in the bit plane. In the combine block of decoder, the values obtained from the pattern fitting block of individual R, G, B components are combined after that all the individual combined block are merged into a single block. Finally compressed image and all the parameter relative to that image will be obtained.

• Discrete Cosine Transform

A discrete cosine transform (DCT) express a finite sequence of data points in expressions of a sum of cosine functions oscillating at different frequencies. DCTs are mainly important to numerous applications in science and engineering, from lossy compression of audio (e.g. MP3) and image (e.g. JPEG) (where small and high frequency components can be rejected), to spectral method for the numerical solution of partial differential equations. The use of cosine function instead of sine is critical for compression, since it turns out (as explained below) that fewer cosine functions are required to approximate a typical signal, where for differential equations cosines function express a particular choice of boundary conditions.

• Error-compensated scalar quantization

The application of ICDF in the TDDC-based coding aims at a better interpolation and a lower compression cost. However, when the compression happens, the interpolation efficiency as well as the coding efficiency will be limited by the distortion occurring on those filtered pixels (denoted as $\sim x$) that will be used for interpolation. To solve this problem, we purpose to reduce the sum of square error (SSE) distortion of $\sim x$ as much as possible via controlling the quantization error of the transformed macro-block based on an error-compensated scalar quantization (ECSQ).

IV. CONCLUSION

Such method is suitable in situations where image or image is compressed once but decoded frequently. It is clear that the decoding time due to spatial domain based compression is much less than that of the sub-band compression techniques. In his paper the study of discrete wavelet transform, discrete cosine transform, multi-level block truncation code and error-compensated scalar quantization technique. Further work of this paper is to implement proposed algorithm in MATLAB software and compare result in base paper.

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