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Lossless Image Compression using Differential Pulse Code Modulation and its Purpose

Chen Yu[1], Rime Raj Singh Tomar[2] and Kapil Jain[3]

[1]Department of Information Engineering, Shenyang University of Chemical Technology, Shenyang, Liaoning, China
[2,3]ITM Universe, Gwalior, India
[1]663928736@qq.com, [2]rimirajsingh@gmail.com, [3]kapiljn5@gmail.com

Abstract

Images include information about the human body which is used for different purposes such as medical, security, and other plans. Compression of images is used in some applications such as profiling data and transmission systems. Regarding about importance of image information, lossless or lossy compression is preferred. Lossless compressions are JPEG, JPEG-LS, and JPEG 2000 are a few well-known methods for lossless compression. We will use differential pulse code modulation for image compression with Huffman encoder, which is one of the latest and provides a good compression ratio, peak signal-noise ratio, and minimum mean square error. In a real-time application that needs hardware implementation, a low complex algorithm accelerates the compression process. In this dissertation, we use differential pulse code modulation for image compression lossless and near-lossless compression method is introduced which is efficient due to its high compression ratio and simplicity. This method is consists of a new transformation method called Enhanced DPCM Transformation (EDT) which has good energy compaction and a suitable Huffman encoding. After introducing this compression method, it is applied to different images from the Corel dataset for experimental results and analysis. As well we compare it with other existing methods for parameter compression ratio, peak signal-noise ratio, and mean square error.

Keywords: *Lossless compression, Image transformation, Prediction method, Encoding technique, DPCM*

1. Introduction

With the advanced development in the internet, teleconferencing, multimedia, and high-definition television technologies, the amount of information that is handled by computers has grown exponentially over the past decades. Hence, storage and transmission of the digital image component of multimedia systems is a major problem. The amount of data requires to present images at an acceptable level of quality is extremely large. High-quality image data requires large amounts of storage space and transmission bandwidth, something that current technology is unable to handle technically and economically. One of the possible solutions is to this problem is to compress the information so that the storage space and transmission time can reduce.

Images are important documents nowadays; images include various information e.g. human bodies in medical images, which are used for different purposes such as medical, security, and other plans. Compression of images is used in some applications such as

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profiling data and transmission systems. To work with them in some applications they need to be compressed, more or less depending on the purpose of the application. About the importance of image information, lossless or lossy compression is preferred. Lossless compressions are JPEG, JPEG-LS, and JPEG2000 are a few well-known methods for lossless compression. We will use differential pulse code modulation for image compression with Huffman encoder, which is one of the latest and provides a good compression ratio, peak signal-noise ratio, and minimum mean square error.

Image compression more or less depends on the purpose of the user's interests. Some algorithms perform this compression in different ways; some are lossless and keep the same information as the original image, some others lose information when compressing the image. Some of these compression methods are designed for specific kinds of images, so they will not be so good for other kinds of images. Some algorithms even let you change the parameters they use to adjust the compression better to the image. Different formats work for each of the images. Some formats match some images better than others depending on what you are looking for to obtain, and the type of image you are working with. The image compression techniques are broadly classified into two categories depending on whether or not a replica of the original image could be reconstructed using the compressed image [9]. These are: (1). Lossless techniques (2). Lossy techniques.

1.1. Classification of image-compression

Image compression schemes can be broadly classified into two types:

1.1.1. Lossless compression (reversible compression)

In lossless compression techniques, the image after compression and decompression is identical to the original image, and every bit of information is preserved during the decomposition process. The reconstructed image after compression is a replica of the original one.

The original image can be perfectly recovered from the compressed or encoded image. These are also called noiseless since they do not add noise to the signal (image). It is also known as entropy coding since it uses statistics/decomposition techniques to eliminate/minimize redundancy. Lossless compression is used only for a few applications with stringent requirements such as medical imaging [10][11].

1.1.2. Lossy compression

In lossy compression, the reconstructed image contains degradations to the original image. Hence, perfect reconstruction of the image is sacrificed by the elimination of some amount of redundancies. Lossy schemes provide much higher compression ratios than lossless schemes. Lossy schemes are widely used since the quality of the reconstructed images is adequate for most applications. By this scheme, the decompressed image is not identical to the original image, but reasonably close to it [10][11].

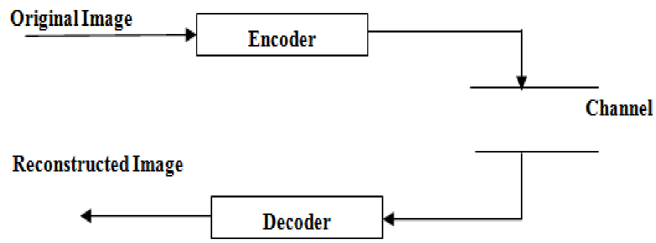

Figure 1. Image compression system block diagram

2. Purpose of image compression methods

The main purpose of image compression is to reduce the size of image data for both storing and transmission. Image compression is mapping from a higher dimensional space to a lower-dimensional space.

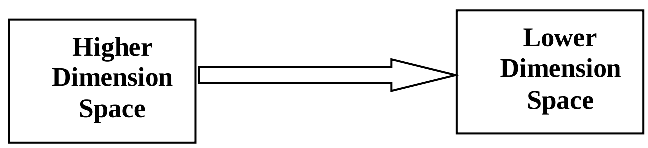

Figure 2. Image compression purpose

3. Related work

In [1], "Multi-Scale Image Compressed Sensing with Optimized Transmission," authors Saheed Olanigan and Lei Cao presented that image Compressed Sensing (CS) often focuses on improving the rate-distortion sensing performance but have less consideration of the effect of channel errors on the transmission of CS measurements. The authors explore how the transmission channel errors affect the PSNR performance of the quantized sensing measurements and then increase the resistance of the transmitted data to the noisy channel. We show that the Multi-Scale Block-Based Compressed Sensing (MSBCS) using quantization with Differential Phase Code Modulation (DPCM), though achieves compression efficiency higher than the regular scalar quantization-based CS, and is more vulnerable to channel errors, and concludes that DPCM-based method in CS though can produce better rate-distortion performance compared to simple SQ-based CS, is more vulnerable to channel errors. Optimal energy allocation methods using both MSE and MAE criteria are proposed and the effect on CS image reconstruction is investigated.

In [2],[7], "A Comparative Study of Effects of CSC on Image Compression Ratios While Using JPEG-XR" and "Shot Cut Detection Based On The Statistical Parameter Histogram With The Discrete Walsh Transform," authors Donapati, S. Yagain, and Jianfeng Wang, proposed an effective and fast shot cut detection algorithm directly in MPEG compressed domain. The proposed shot cut detection test the difference between the current frame and the next frame by extracting the feature of each frame. When extracting the features of the frame, statistical parameters m1-σ from DWT coefficients without its inverse transform were computed, Except this, locating shot cuts is operated by comparison tests. In comparison with the latest research efforts in shot cut detection, our proposed algorithm achieves significant advantages including (a) using the Walsh transform to reduce the computation time for a given resolution or to increase the resolution without drastically increasing the computation time (b) there is no full decompression is needed (c) adding correlation to judge the difference between feature vectors and (d) detection performance is competitive and fast.

In [3], “Efficient Medical Image Compression Technique for Telemedicine Considering Online and Offline Application,” authors Adina Arthur, V. Saravanan presented that the transformation methods such as Differential Pulse Code Modulation (DPCM), and prediction improved the DPCM transformation step of compression and introduced a transformation which is efficient in both entropy reduction and computational complexity. A new method is then achieved by improving the prediction model which is used in lossless JPEG. The prediction improved transformation increases the energy compaction of the prediction model and as a result, reduces the entropy value of the transformed image. After transforming the image Huffman encoding is used to compress the image. As a result, the new algorithm shows a better efficiency for lossless compression of medical images, especially for online applications, and concludes that different transforms namely DPCM and improved DPCM transformation method and the compression percentage could be evaluated. It also helps in the secure transmission of data.

In [4], **“**Digital Image Compression Comparisons using DPCM and DPCM with LMS Algorithm,” authors Ranbeer Tyagi, D. K. Sharma presented that the DPCM and LMS may be used to remove the unused bit in the image for image compression. In this paper Authors compare the compressed image results for 1 and 3 bits DPCM Quantization and DPCM with LMS Algorithm and also compare the histogram, prediction mean square using DPCM Quantization and DPCM with LMS Algorithm for approximately the same distortion levels. The LMS may provide almost 2 bits per pixel reduction in transmitted bit rate compared to DPCM when distortion levels are approximately the same distortion for both methods. The LMS Algorithm may be used to adapt the coefficients of an adaptive prediction filter for image source coding. In the method used in this paper, we decrease the compressed Image size, distortion, and also estimation error, and conclude by using weight coefficient DPCM and the LMS uses the adaptive coefficient for image compression with the same distortion level. A comparison of using DPCM and using DPCM with LMS algorithm to image compression has been carried out based on their coefficient and the number of bits. Results are presented which show LMS may provide more reduction in transmitted bit rate compared to DPCM when distortion levels are approximately the same for both methods. The results show that the LMS algorithm has the least computational complexity but more reduction in the compressed image compared to DPCM with the same distortion. The LMS can be used in fixed bit-rate environments to decrease the reconstructed Image size and distortion.

In [5], "Improved H.264/Avc Lossless Intra Compression Using Multiple Partition Prediction For 4×4 Intra Block," authors Sang Heon Lee, Jewoong Ryu, and Nam Ik Cho, presented that DPCM is an important prediction technique for the lossless intra compression. A new prediction method that is more efficient than the conventional DPCM, thereby improving the overall compression performance. The proposed method prepares 5 partition patterns for each 4×4 block such as 4×4 (no partition), 4×2, 2×4, 2×2, and 1×1. The pixels in each partition is intra predicted by DPCM and the best partition which produces the minimum bit is selected as the partition pattern for the 4×4 block. Also, the number of available intra prediction directions is determined according to the partition pattern to avoid too much side-information transmission. They conclude that the proposed method gives 3.62 % point bit rate saving on average and 4.74 % point bit rate saving at maximum compared to the conventional DPCM and conclude that new prediction scheme for improving the performance of lossless image compression. Unlike the conventional methods that use 4×4 block only, the proposed method partitions the block and applies different prediction directions depending on the block properties. The partition pattern and the prediction direction for each sub-block are found based on the rate minimization considering the side information.

In [8], "A New Lossless Method of Image Compression and Decompression Using Huffman Coding Technique," authors Jagadish H. Pujar, Lohit M. Kadlaskar, proposed the Lossless method of image compression and decompression using a simple coding technique called Huffman coding. This technique is simple in implementation and utilizes less memory. A software algorithm has been developed and implemented to compress and decompress the given image using Huffman coding techniques in a MATLAB platform.

4. Proposed method

In the overall technique in the first step, we will apply a new transformation method that is different from the previous transformation. In the next step apply Huffman encoding suitable for that transformation.

(a) Transformation. This method is based on predictive models. However, more energy compaction is obtained by improving prediction ability. Energy compaction and complexity are a few important attributes of any good transformation. This requirement meets by changing some hardware implementation.

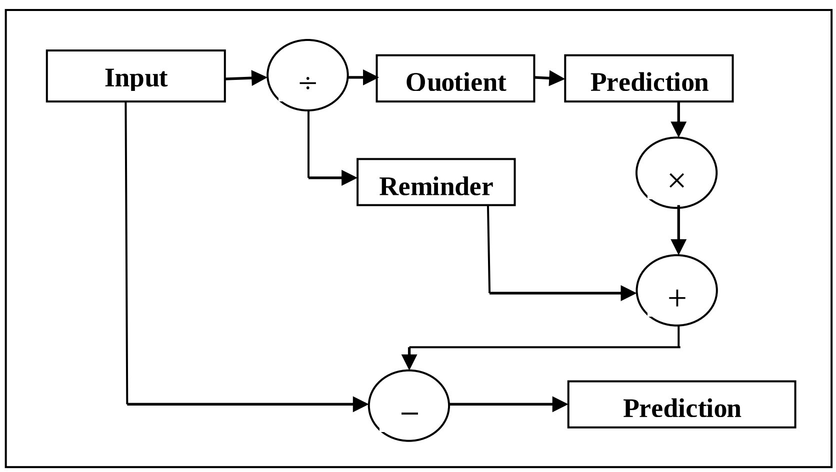

Figure 3. Block diagram of the new transformation method

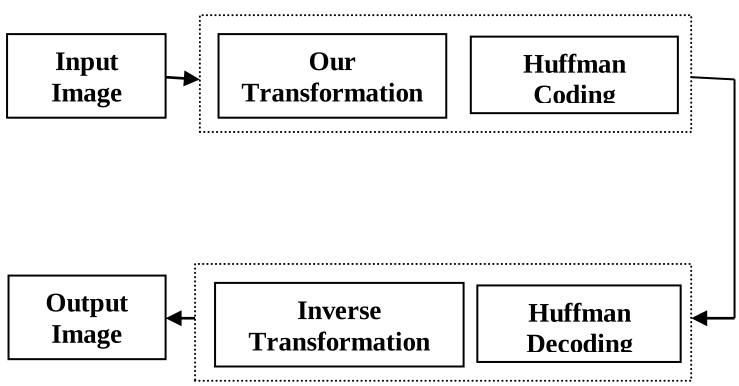

Figure 4. Compression and decompression scheme of the proposed method

Descriptions of the Block Diagram are given below:

Step1: Division is first applied to the input image. Then, quotients of division are being predicted by one of the prediction equations. Neighboring Pixels in DPCM and Prediction Equations. Further, the predicted matrix is re-scaled in the multiplication step.

Step2: By adding a predicted matrix with the remainders of the division step, the predicted image is produced. Subtraction of predicted image from original image gives prediction error matrix which is transformed image.

Step3: The input image is divided by n and rounded quotient and the remainder of the division is kept in Quotient and Remainder respectively. We chose divisor in a fashion that the sum of quotient depth and remainder depth is equal to input image depth. Therefore, in an 8-bit depth image, the divisor is a power of two and smaller than the biggest possible intensity value.
Abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

5. Expected outcome

In this section, we are showing our results in GUI format. Here we are implementing our result in four blocks which are explained one by one. In Input Block, we can browse an image from any location and put it into a variable. When the image is stored in a variable then we can apply any image operation. In the same block, we will find the entropy of an image. In DPCM Encoding Block we apply the DPCM Encoding technique since we know that in our methods we have to apply quantization to a given image. During the quantization process, we will have an error. In Quantization Function: A function that is used to change a sampled image into a digital value is known as Quantization Function. Most of the digital image processing devices are quantization into K equal intervals. If b bits are used the number of brightness levels is $K = 2^b$.

6. Conclusion

In this thesis, we introduced a new method of compression which is based on EDT and Huffman entropy encoding. However, the compression ratio of the proposed method is more powerful than a few previous methods. This method is suitable for real-time applications. The comparison was based on compression efficiency which is compression ratio and computational complexity. To understand the efficiency of the new method for medical compression and real-time application of medical imaging such as telemedicine and online diagnosis, we test our method on medical test cases either. Therefore, it can be efficient for lossless compression and implementation for lossless or near-lossless medical image compression. Further, we compare this method with previous JPEG standards such as lossless JPEG and JPEG2000. As it has been proved and illustrated by simulations, the new compression method causes a good compression ratio and improves older methods. The compression ratio improvement helps transmission systems to work faster and helps the real-time process. On the other hand, it is a low-complex method despite its compression ability.

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