Comparison of Error Diffusion Block Truncation Coding with Block Truncation Coding Technique

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ABSTRACT

In today’s digital world, providing increased data amount in the limited bandwidth is a challenging task. It requires a powerful digital compression scheme to satisfy the vast requirement of users. Block Truncation Coding (BTC) has been used for many years for coding digital images for the purposes of transmission and storage. It uses moment preserving quantization method for compressing digital grayscale images. Even though this method retains the visual quality of the reconstructed image with good compression ratio, it shows some artifacts like blocking effect and false contouring. Various schemes of block truncation coding using digital halftoning techniques like ordered dithering, error diffusion, and dot diffusion have been proposed to improve the quality of BTC. Experimental result shows that as compared to the traditional BTC technique image compression employing digital halftoning i.e Error Diffusion Block Truncation Coding (EDBTC) provided excellent image quality and artifact-free results.

Keywords— BTC, Digital halftoning, EDBTC

I. INTRODUCTION

The amount of image data grows day by day. Large storage and bandwidth are needed to store and transmit the images, which is quite costly. Hence methods to compress the image data are necessary. The image compression techniques are categorized into two main categories namely Lossy compression techniques and Lossless compression techniques. Lossless compression ratio gives good quality of compressed images, but yields only less compression whereas the lossy compression techniques lead to loss of data with higher compression ratio. JPEG and Block Truncation Coding are lossy image compression techniques. It is a simple technique which involves less computational complexity. BTC is a recent technique used for compression of monochrome image data. It is one-bit adaptive moment-preserving quantizer that preserves certain statistical moments of small blocks of the input image in the quantized output.

The block truncation coding (BTC) technique for image compression has the advantage of being easy to implement compared to other block based compression methods such as transform coding and vector quantization. In BTC, an image is divided into fixed-size blocks (IBTC) and a two level quantizer is applied to the pixels of each block. The drawback of IBTC is that the block size may need to be uniformly small in order to avoid edge blurring and creating block lines in smooth areas. Therefore, a higher compression ratio may not be achieved if large parts of the image do not contain any details and are merely uniform areas. For the same bit rate, the vBTC (Variable Block Truncation Coding) produced reconstructed images with less error than the images reconstructed by IBTC. It is also noted that in BTC algorithms, the use of the mean of pixel values within the block as a threshold is not optimal in the sense of minimizing the error in the reconstructed images. vBTC also enhances the visual quality of the image due to its division strategy in treating image areas with different levels of details.

The concept of the BTC is to look for a simple set of representative vectors to replace the original images. The BTC compresses an image into a new domain by dividing the original image into multiple non-overlapped image blocks, and each block is then represented with two extreme quantizers (i.e., high and low mean values) and bitmap image. Two subimages constructed by the two quantizers and the corresponding bitmap image are produced at the end of BTC encoding stage, which are later transmitted into the decoder module through the transmitter. To generate the bitmap image, the BTC scheme performs thresholding operation using the mean value of each image block such that a pixel value greater than the mean value is regarded as 1 (white pixel) and vice versa.

Even though the BTC scheme needs low computational complexity, it often suffers from blocking effect and false contour problems, making it less satisfactory for human perception. The halftoning-based BTC, namely, error diffusion BTC (EDBTC), is proposed to overcome the two above disadvantages of the BTC. Similar to the BTC scheme, EDBTC looks for a new representation (i.e., two quantizers and bitmap image) for reducing the storage requirement.
II. PROPOSED SYSTEM

The EDBTC compresses an image in an effective way by incorporating the error diffusion kernel to generate a bitmap image. For each image block, the EDBTC produces a single bitmap image and two extreme quantizers. The bitmap image size is identical to that of the original image size. EDBTC employs the error kernel to generate the representative bitmap image.

Fig. 1. Proposed EDBTC technique for color image

The EDBTC exploits the dithering property of the error diffusion to overcome the false contour problem normally occurred in BTC compression. Moreover, the blocking effect can also be eased by its error kernel since the quantization error on one side of the boundary can be compensated by the other side of the boundary. The correlation on both sides of a boundary between any pair of resulting image blocks can be maintained. The EDBTC bitmap image can be obtained by performing thresholding of the interband average value with the error kernel.

The minimum, maximum, and mean value of the inter-band average pixels were computed as follows,

\[
x_{\text{min}} = \min f(x, y); \forall x, y
\]

\[
x_{\text{max}} = \max f(x, y); \forall x, y
\]

\[
\bar{x} = \frac{1}{mn} \sum_{x=1}^{m} \sum_{y=1}^{n} f(x, y);
\]

The EDBTC thresholding process is performed in a consecutive way. One pixel is only processed once, and the residual quantization error is diffused and accumulated into the neighboring unprocessed pixel.

III. PERFORMANCE COMPARISON

The test was conducted on an image of size 720x720 and the simulation was carried out in Matlab. Figure 5.1 shows the cropped results of the test images. The images are compressed by both BTC and EDBTC algorithms and the results are displayed for comparison.

The quality evaluation involved in this study is defined as follows:

\[
\text{PSNR} = 10 \times \log \frac{255^2}{\frac{1}{T} \sum_{i=1}^{m} \sum_{j=1}^{n} (x_{ij} - x'_{ij})^2}
\]

Where the variables \(x_{ij}\) and \(x'_{ij}\) represent the original pixel value and the decoded value at position \((i, j)\) respectively; and \(T\) represents the total number of pixels. Higher the PSNR (Peak Signal to Noise Ratio) value indicates better image quality.

Fig. 3.1 shows an image quality comparison of the EDBTC reconstructed image under Floyd-Steinberg error kernel over various image block size. Compared with the BTC scheme, the EDBTC overcomes the blocking effect and false contour artifacts in the reconstructed image. To demonstrate the effectiveness of the proposed EDBTC image compression method as compared to traditional BTC, reconstructed image quality analysis of the images were conducted for the two techniques.

In this experiment, the quality of images is measured using PSNR (Peak Signal to Noise Ratio). Higher the PSNR value indicates better image quality. Table I. shows the PSNR values of different reconstructed images in the two techniques (BTC and EDBTC). It is found that EDBTC produces a higher PSNR value compared to BTC. As is evident from the experimental results, the image quality of the EDBTC is superior to BTC. The performance can be attributed to diffusion of residual quantization error into the neighboring unprocessed pixels. Fig. 3.2 shows comparative analysis of PSNR values between EDBTC and BTC schemes.

<table>
<thead>
<tr>
<th>Method</th>
<th>PSNR(dB), 2x2</th>
<th>PSNR(dB), 4x4</th>
<th>PSNR(dB), 8x8</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTC</td>
<td>19.965</td>
<td>22.7347</td>
<td>20.632</td>
</tr>
<tr>
<td>EDBTC</td>
<td>32.1022</td>
<td>25.9878</td>
<td>21.3385</td>
</tr>
</tbody>
</table>

Fig. 3.1. Reconstruction image quality comparison of EDBTC (first row) and BTC (second row) over image block sizes (from first and second column) 2, 4 and 8 respectively.
IV. CONCLUSION

This study presented error diffusion based BTC image compression techniques which can provide an excellent image quality and artifact-free results as compared to traditional BTC. Two algorithms were selected namely, the original Block Truncation Coding (BTC) and Error Diffusion Block Truncation Coding (EDBTC) to generate the experimental results. The two algorithms are based on dividing the image into non-overlapping blocks. As is evident from the experimental results, the image quality of the EDBTC is superior to BTC which is shown by a higher PSNR value. The performance can be attributed to diffusion of residual quantization error into the neighboring unprocessed pixels. Some applications have been proposed in the literature triggered by the successfulness of EDBTC, such as image watermarking, inverse halftoning, data hiding, image security, and halftone classification. The EDBTC scheme performs well in those areas with promising results, since it provides better reconstructed image quality than that of the BTC scheme.

REFERENCES