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Partial Adaptive Multi-Level Block Truncation Coding (Ambtc) Of Spinal X-Ray Image For Efficient Compression

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Abstract

This study aims to explore various adaptations of the Adaptive Multi-Level Block Truncation Coding (AMBTC) compression model applied to lumbar spine radiographic images, focusing on minimizing image size while preserving essential information. The approach involves adjusting several technical aspects of the AMBTC model, including the number of blocks, block size, and compression rate. The quality of the compressed images is assessed using image quality metrics such as PSNR (Peak Signal-to-Noise Ratio) and MSE (Mean Squared Error). The findings indicate that a modified AMBTC compression model can significantly enhance the quality of lumbar spine radiographic images, evidenced by increased PSNR values, while substantially reducing the file size without compromising crucial image details.

Keywords: *AMBTC, Lumbar Spine, Radiographic*

1. Introduction

As a form of visual information, the figurative components of multimedia play a crucial role. Unlike textual data, images are rich in information. The saying "a picture is worth a thousand words" underscores the notion that an image can convey more information than text could [1]. There are numerous image compression techniques available, one of which is AMBTC.

The AMBTC technique processes image blocks in groups of three, each consisting of two quantization levels and a non-uniformly distributed bitmap. However, the pervasive errors in bitmap distribution led to significant image quality degradation during information embedding. By utilizing a reference table loaded with symmetrical examples, the proposed strategy employs a symmetry alteration model to adjust quantization levels in these blocks, achieving minimal distortion [2].

Since their discovery in 1895, X-rays have been used for non-invasive, high-resolution imaging of dense biological objects [3]. They are commonly employed for imaging bone structures, metal implants, and soft tissue cavities. Recent developments in various contrast methods have expanded the biomedical applications of X-rays to include both functional and structural imaging [4]. These methods have the potential to enhance our ability to study the biochemistry of diseases in situ and understand pathophysiology [5].

AMBTC is an efficient method for compressing images, and this study specifically explores its application to lumbar spine radiographic images. The goal is to implement various AMBTC compression model variations that reduce image size without sacrificing essential information in the lumbar spine radiographs. This involves dividing the image into uniform blocks, each encoded using a threshold derived from the average pixel values within the block. AMBTC is known to achieve superior compression rates compared to other methods such as Discrete Cosine Transform (DCT) and Run Length Encoding (RLE).

In security systems like facial recognition and pattern matching, the benefits of AMBTC are particularly notable as it reduces the data volume, thus speeding up the recognition process [2]. Additionally, AMBTC is applied to improve data compression and enhance processing efficiency in image and video processing tasks, including object recognition [6].

The study also investigates advancements in the AMBTC technique by increasing the bitplane element size and the number of quantizers from two to four, leading to a higher bits per pixel (bpp) ratio. This modification involves compressing the bit field twice to boost encoding efficiency and reducing the size of the statistical moment from 8 bits to 6 bits. These adjustments have resulted in a substantial increase in the Peak Signal-to-Noise Ratio (PSNR) values, according to the proposed strategy. This enhanced AMBTC framework is integrated into the current model, offering three different levels of encoding efficiency, allowing users to select from four compression levels based on their specific needs [7]. This research aims to refine these modifications to better serve the critical requirements of lumbar spine radiographic imaging.

2. Method

In the methodology section of this study, we utilized a customized AMBTC approach to compress lumbar spine radiographic images. The original AMBTC technique involves lossy compression, where data loss occurs as the image is compressed. It employs a block-based image encoding method that requires less memory and simpler computations, making it efficient for such applications [8], [9]. In this study, before applying the compression, the type is chosen first. As shown in Figure 1, the step is in Block Condition for customization step.

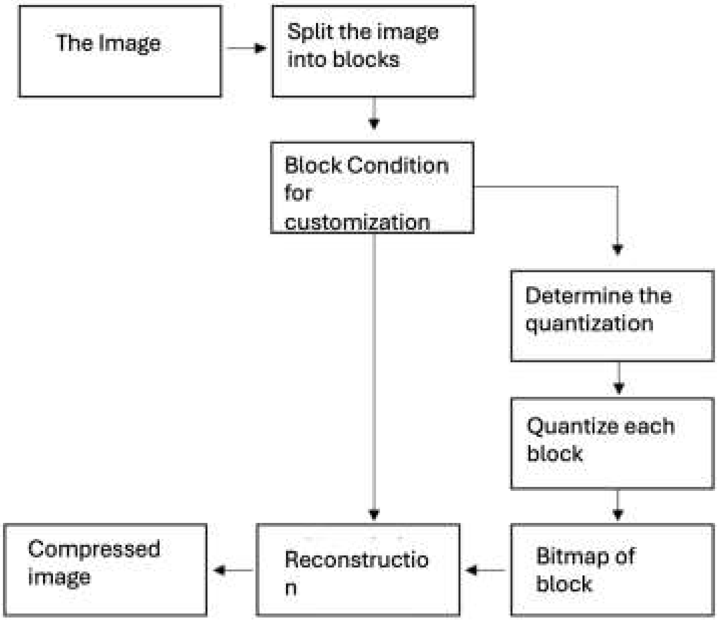

Figure 1. Customized AMBTC Flowchart

The customization of AMBTC in this study includes variations such as partial, left-right, full (original AMBTC), and top-down compression as shown in Figure 2. These variations specifically aim to maintain high-quality imaging in the central region of the x-ray images, which is critical for spinal analysis. The peripheral areas of the image, such as the left, right, top, and bottom sections, are subjected to higher levels of compression. This strategy leverages the simplicity of AMBTC's computation to reduce file size significantly while ensuring that essential diagnostic details in the central part are preserved.

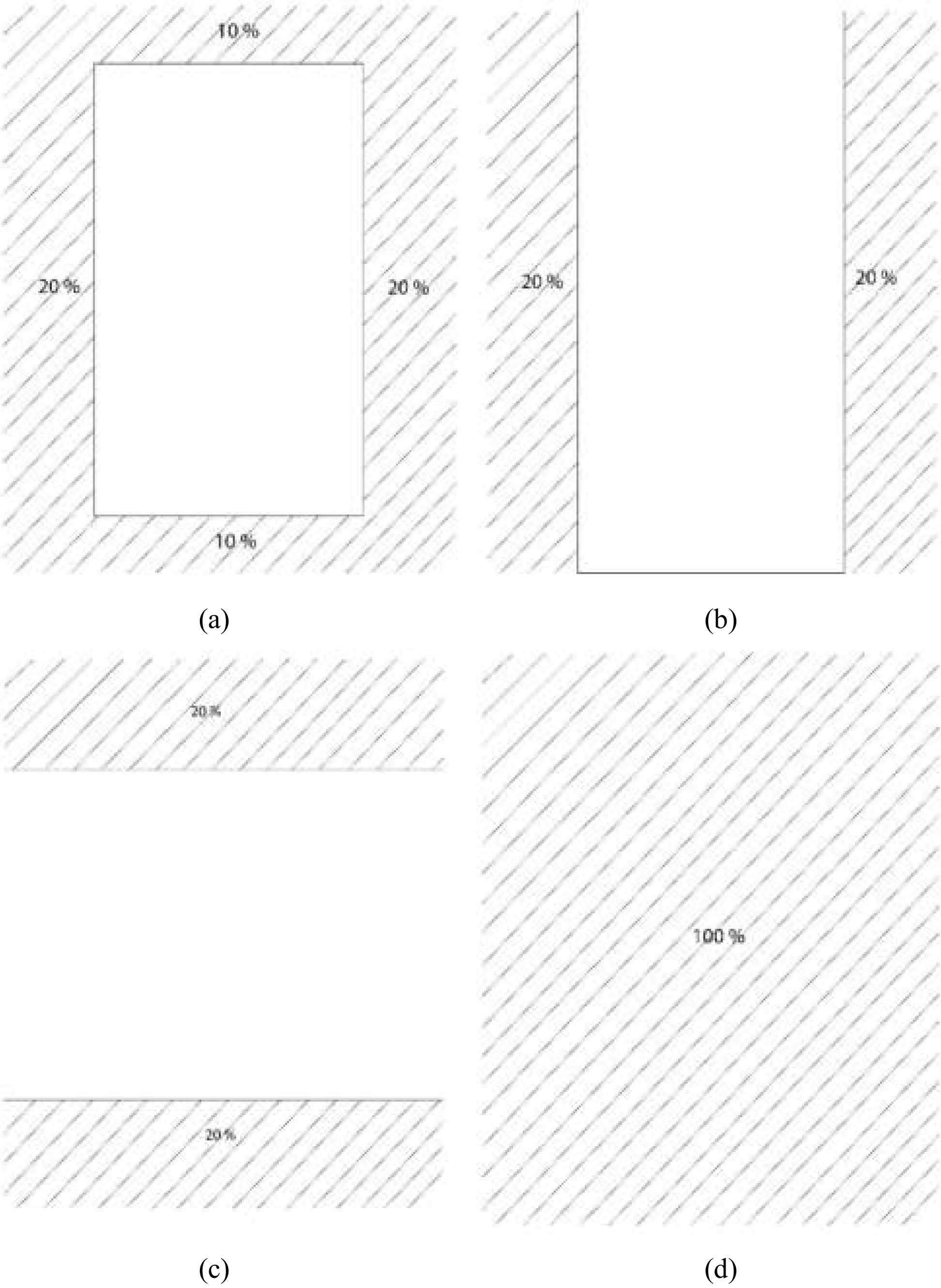

Figure 2. The customized AMBTC processed part: (a) partial, (b) left-right partial, (c) top-down partial, (d) full (original AMBTC).

Further, the Absolute Moment Block Truncation (AMBTC) encoding for image compression and performance indicators like compression ratio, SNR, MSE, and PSNR for different block sizes was investigated. This method compresses color image data using AMBTC, which minimizes computational complexity while achieving the best root mean square error and optimal PSNR. It represents an enhanced version of BTC, achieved by saving absolute moments. With block sizes of 8, 16, and 32, AMBTC compression provides higher image quality compared to BTC image compression [10]. This selective compression approach optimizes the balance between maintaining critical image quality and enhancing compression efficiency.

3. Results and Discussions

In this chapter, the results of applying each type of customized AMBTC for lumbar spine radiographic image are discussed. As shown in Figure 3, the original image and the AMBTC compressed images are depicted.

(a)

(b)

(c)

(d)

(e)

Figure 3. List of images (a) original image; (b) the partial compression; (c) the left-right compression; (d) the top-down compression; (e) the full compression.

Table 1. Comparison of PSNR test results

	Sample	Full Compression	Partial Compression	Left-right Compression	Top-down Compression
1	Image 1	37.19 dB	38.07 dB	38.31 dB	38.17 dB
2	Image 2	38.15 dB	39.11 dB	39.40 dB	39.19 dB
3	Image 3	37.11 dB	38.01 dB	38.25 dB	38.06 dB
4	Image 4	36.37 dB	37.11 dB	37.33 dB	38.16 dB
5	Image 5	36.78 dB	37.57 dB	37.77 dB	37.70 dB
6	Image 6	36.76 dB	37.44 dB	37.68 dB	37.54 dB
7	Image 7	37.43 dB	38.27 dB	38.51 dB	38.58 dB
8	Image 8	35.18 dB	35.74 dB	35.91 dB	35.79 dB
9	Image 9	38.36 dB	39.26 dB	39.56 dB	39.39 dB
10	Image 10	38.68 dB	39.72 dB	40.02 dB	40.30 dB

3.1 PSNR Test

PSNR (Peak Signal-to-Noise Ratio) is commonly used to measure the efficiency of compressors, filters, and similar devices. A higher PSNR indicates a more efficient compression or filtering approach [11]. There was no significant difference in PSNR values among Full Compression, Partial Compression, Left-Right Compression, and Top-Bottom Compression. All methods demonstrated good signal recovery levels, with average PSNR values exceeding 35 dB. However, it is important to note that the higher the PSNR value, the better the quality of image recovery after compression. The result for 10 samples is listed in Table 1.

3.2 MSE Test

MSE is used to determine how accurate an estimate or projection is. The lower the MSE, the closer the forecast is to reality [12]. This is a model evaluation metric for regression models, with lower values indicating better fit. Table 2 shows the test results for 10 images.

Table 2. Comparison of MSE test results

	Sample	Full Compression	Partial Compression	Left-right Compression	Top-down Compression
1	Image 1	11.14	9.07	8.57	8.92
2	Image 2	9.09	7.25	6.78	7.09
3	Image 3	10.45	8.60	8.18	8.52
4	Image 4	12.49	10.49	9.93	8.81
5	Image 5	12.13	10.24	9.93	10.01
6	Image 6	12.37	10.63	10.14	10.35
7	Image 7	10.19	8.40	7.95	7.94
8	Image 8	17.49	15.65	15.15	15.49
9	Image 9	8.66	7.02	6.58	6.84
10	Image 10	7.31	5.70	5.29	5.13

3.3 File Size Comparison

Table 3. Size comparison of the resulted files

	Sample	Full Compression	Partial Compression	Left-right Compression	Top-down Compression
1	1.898 KB	453 KB	444 KB	445 KB	421 KB
2	2.059 KB	372 KB	355 KB	349 KB	344 KB
3	2.223 KB	420 KB	419 KB	415 KB	403 KB
4	2.133 KB	531 KB	517 KB	513 KB	435 KB
5	2.110 KB	493 KB	485 KB	482 KB	462 KB
6	2.062 KB	410 KB	302 KB	397 KB	393 KB
7	2.113 KB	438 KB	329 KB	428 KB	399 KB
8	2.559 KB	565 KB	580 KB	582 KB	561 KB
9	1.850 KB	356 KB	345 KB	336 KB	326 KB
10	1.947 KB	391 KB	364 KB	357 KB	331 KB

Based on the data provided in Table 3, it can be concluded that all four compression methods (full compression, partial compression, right-left compression, and top-down compression) provide a significant reduction in file size. The average percentage reduction in file size of about 78.96% shows that these methods are effective in compressing data. Although there is slight variation in file size reduction results between these methods, they all provide good efficiency. Even so, it is important to consider other factors such as image quality, compression time, and available resources when choosing the most suitable compression method for specific needs. With this understanding, users can optimize file size by choosing the right compression method.

4. Conclusions

Adaptive Multi-Bit Transform Coding (AMBTC) was employed to develop various compression model variations in this thesis. The primary goal was to evaluate the modifications to the AMBTC model and analyze their performance in terms of compression ratio and image reconstruction quality. The testing and evaluation revealed that the modified AMBTC models could enhance the compression ratio compared to the original AMBTC. Additionally, certain model modifications demonstrated improvements in image reconstruction quality. These findings suggest that developing variant models of AMBTC can offer superior options for image compression. However, it is crucial to recognize that each model variant has its respective strengths and weaknesses. Some may excel in compression ratio, while others might improve reconstruction quality. Therefore, selecting the appropriate model variant should depend on specific needs and the intended application of image compression.

While the developed variations of the AMBTC compression model mark significant progress, they are not without flaws, indicating potential areas for further refinement. Recommendations for future work includes Exploring complementary compression methods to achieve better compression ratios. Enhancements might involve alterations in transformation strategies, encoding techniques, or the implementation of more efficient predictive models. Addressing the issue of black spots observed in partial compressions, which indicate suboptimal outcomes from the current program. Efforts should be made to eliminate these artifacts in partial image compressions to improve the overall image quality.

References

[1] A. Gerard and B. Goldstein, *Going visual: Using images to enhance productivity, decision-making and profits*. John Wiley & Sons, 2005. Accessed: May 19, 2024. [Online]. Available: https://books.google.com/books?hl=id&lr=&id=zSXP2Bg0LEkC&oi=fnd&pg=PR3&dq=The+saying+%22a+picture+is+worth+a+thousand+words%22+underscores+the+notion+that+an+image+can+convey+more+information+than+text+could&ots=DvcfcgEhqi&sig=9VzB-toQYQBfER0GExalabo7aTU

[2] M. Tang, S. Zeng, X. Chen, J. Hu, and Y. Du, "An adaptive image steganography using AMBTC compression and interpolation technique," *Optik*, vol. 127, no. 1, pp. 471–477, 2016.

[3] P. V. Rodrigues *et al.*, "Illuminating the brain with X-Rays: Contributions and future perspectives of high-resolution microtomography to neuroscience," *Front. Neurosci.*, vol. 15, p. 627994, 2021.

[4] J. Wallyn, N. Anton, S. Akram, and T. F. Vandamme, “Biomedical imaging: principles, technologies, clinical aspects, contrast agents, limitations and future trends in nanomedicines,” *Pharm. Res.*, vol. 36, pp. 1–31, 2019.
[5] H. Chen, M. M. Rogalski, and J. N. Anker, “Advances in functional X-ray imaging techniques and contrast agents,” *Phys. Chem. Chem. Phys.*, vol. 14, no. 39, pp. 13469–13486, 2012.
[6] W. Hong, D. Li, D.-C. Lou, X. Zhou, and C.-H. Chang, “A bit toggling approach for AMBTC tamper detection scheme with high image fidelity,” *PloS One*, vol. 15, no. 4, p. e0230997, 2020.
[7] K. Somasundaram and S. Vimala, “Multi-Level Coding Efficiency with Improved Quality for Image Compression based on AMBTC.” arXiv, Apr. 07, 2012. Accessed: May 19, 2024. [Online]. Available: http://arxiv.org/abs/1204.1704
[8] I. M. Spiliotis and B. G. Mertzios, “Real-time computation of two-dimensional moments on binary images using image block representation,” *IEEE Trans. Image Process.*, vol. 7, no. 11, pp. 1609–1615, 1998.
[9] W. A. Pearlman, A. Islam, N. Nagaraj, and A. Said, “Efficient, low-complexity image coding with a set-partitioning embedded block coder,” *IEEE Trans. Circuits Syst. Video Technol.*, vol. 14, no. 11, pp. 1219–1235, 2004.
[10] S. Vimala, B. J. Chitra, and P. Uma, “Multilevel Splitting of Images to Improve Coding Efficiency for AMBTC,” *Int. J. Adv. Eng. Res. Sci.*, vol. 3, no. 5, p. 236717.
[11] S.-Y. Lee and A. Ortega, “A novel approach of image compression in digital cameras with a Bayer color filter array,” in *Proceedings 2001 International Conference on Image Processing (Cat. No. 01CH37205)*, IEEE, 2001, pp. 482–485. Accessed: May 22, 2024. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/958156/
[12] J. Qiu, B. Wang, and C. Zhou, “Forecasting stock prices with long-short term memory neural network based on attention mechanism,” *PloS One*, vol. 15, no. 1, p. e0227222, 2020.