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A Study of Lossless Compression Techniques for Medical Images

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ABSTRACT

Lossless compression techniques for medical images play a critical role in modern healthcare by enabling efficient storage and transmission of high-resolution diagnostic data without any degradation of image quality. In medical imaging, where precise detail is essential for accurate diagnosis, even minimal loss of data can lead to misinterpretation. Therefore, lossless compression algorithms ensure that the original image can be perfectly reconstructed from the compressed data. Techniques such as Huffman Coding, Arithmetic Coding, Run-Length Encoding (RLE), and more advanced methods like JPEG-LS, JPEG 2000 (in lossless mode), and wavelet-based algorithms have proven effective in maintaining data integrity. These methods exploit spatial and statistical redundancies within images to reduce file sizes while preserving all original information. Particularly in modalities like MRI, CT, and X-rays, where large volumes of image data are generated, lossless compression supports better management of storage and bandwidth without compromising diagnostic value. Furthermore, with the growing adoption of telemedicine, Picture Archiving and Communication Systems (PACS), and electronic health records, the demand for reliable and efficient lossless compression is increasing. This study explores various lossless techniques, evaluates their compression ratios and performance on medical datasets, and highlights the importance of balancing compression efficiency with clinical requirements for accurate, high-fidelity imaging.