A Metaheuristic Approach for Tetrolet-Based Medical Image Compression

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ABSTRACT

Medical imaging plays a significant role in clinical practices. Storing and transferring the huge volume of images becomes complicated without an efficient image compression technique. This paper proposes a compression algorithm that uses a Haar-based wavelet transform called Tetrolet transform, which reduces the noise on the input images and decomposes with 4 x 4 blocks of equal squares called tetrominoes. It opts for a decomposing using optimal scheme for achieving the input image into a sparse representation which gives a much-detailed performance for texture and edge information better than wavelet transform. Set partitioning in hierarchical trees (SPIHT) is used for encoding the significant coefficients to achieve efficient image compression. It has been investigated with various metaheuristic algorithms. Experimental results prove that the proposed method outperforms the other transform-based compression in terms of PSNR, CR, and complexity. Also, the proposed method shows an improved result with another state of work.

KEYWORDS

Medical Image Compression, Metaheuristic Algorithm, SPIHT, Tetrolet Transform

1. INTRODUCTION

Over recent years, there has been a huge series of images that are getting generated in hospitals to diagnose various diseases. Doctors / Clinicians prefer to judge the illness of the patients through the images generated of internal organs. These Medical images are often generated using acquisition devices such as CT scan, MRI, X-Ray, Etc., Commonly these medical images are volumetric in size which requires high storage (Gonzalez et al., 2009). Speed and Bandwidth are the major setbacks as considered while transmitting the medical images (Smith-Bindman et al., 2008) for telemedicine. This problem can be overcome by compressing a medical image effectively. Digital image compression achieves the redundancy in an image that can be represented using a smaller number of bits to acquire an acceptable quality image. Compression deals with two variety of methods such as Lossy compression and Lossless compression. Generally, images used in a medical domain need to be compressed without losing the data (Khalaf, Abdulsahib, Kasmaei, et al., 2020) for better diagnosis, which directs an efficient lossless medical image compression algorithm.

Even a vast number of algorithms were already proposed for finding an efficient compression algorithm, still finding a lossless medical image compression algorithm is a challenging task. The

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performance of the lossless algorithm is measured using the ratio bit rate required for the original input image to its compressed image called compression ratio (CR). Bit rate is defined by an average number of bits essential to represent each pixel of the compressed image. Subjective and Objective quality measures are also considered over compression. Popular transforms such as Wavelet and JPEG based algorithm achieves a high compression ratio but failed to maintain the quality of the image. As the main drawback states that algorithms are irreversible, this paper proposes a compression method for medical images using a Haar wavelet-based transform called Tetrolet (Krommweh, 2010). This method decomposes the input medical images into blocks to find a sparsest tetrolet representation over the image and encodes with (SPIHT) Set partitioning hierarchical tree method (Dragotti et al., 2000).

The proposed method is analyzed by comparing its performances through different metrics with metaheuristic algorithms and also with transform-based compression methods (Saravanan et al., 2013),(Juliet et al., 2016) and (Uma Vetri Selvi & Nadarajan, 2017) with a dataset of medical images. Experimental results prove that the proposed method achieves a higher value with various performance metrics such as peak signal-noise ratio (PSNR), Compression Ratio (CR), and Computational time (CT) over other algorithms. This paper is arranged as follows: Section 2 deals with related works over the different compression transforms followed by Section 3 that describes the proposed method with Tetrolet transform and SPIHT encoder. Section 4 details the performance analysis of the proposed algorithm over other methods with various metrics. Section 5 deals with the Results and discussion of the compression algorithms and finally conclusions are given in section 6.

2. RELATED WORKS

To obtain an efficient algorithm for achieving a better visual quality medical image, there has been an enormous number of algorithms identified. It has been widely classified as lossy and lossless compression(Hussain et al., 2018). Transform based compression are popular which transforms the image from one domain (spatial/temporal) to a different type of representation. Then the values are coded to achieve good quality image data. To reduce the correlation between the pixels in an image is also an important factor when we analyze the transform-based coding such a DCT, DFT, and DWT. DCT(Gupta et al., 2014) declares quantization as an essential sector which deals with reducing the number of bits to store the transformed values. However, quantization makes the algorithm lossy. DFT (Hao & Shi, 2001) decomposes a complex signal into a weighted sum of zero frequency term. Wavelet-based compression, DWT(Wu, 2014) overcomes the blocking effect limitation in DCT. It generally works on the function that integrates to a zero waving over the x-axis and also results in better values over the other algorithms. Based on the wavelet transform, there are many other forms of transforms derived such as Haar wavelet (Harikrishnan et al., 2017) that isolate the image into segments, and the detail is achieved through averaging and differencing. Daubechies (Nagendran & Vasuki, 2019) proposed wavelet (dB1, dB4) which focused on dividing into constituents namely split, prediction, and update method. Bandelet (Yang et al., 2014), Contourlet (Uma Vetri Selvi & Nadarajan, 2017), Curvelet (Saravanan et al., 2013), Noislet (Wen et al., 2010), Wedgelet (Romberg et al., 2002), Chirplet (Mann & Haykin, 1995), Tetrolet (Krommweh, 2010), etc are also the other wavelet-based lets which are derived based on parameters of multiscale, Directionality, Geometric representations(Jacques et al., 2011).

For an efficient representation of geometric features over the images, these star-lets were originated. Ridgelets (Jacques et al., 2011) is a combination of a one-dimensional wavelet transform and a radon transform that focuses on the efficient representation of discontinuities over straight lines. Curvelet (Rupa et al., 2014; Saravanan et al., 2013) is identified to enable the efficient representation of two-dimensional singularities along arbitrarily shapes curves over the image. Contourlets (Uma Vetri Selvi & Nadarajan, 2017) are considered as a low redundancy discrete approximation of curvelets which are designed in a spatial domain to achieve the close to critical directional representation. Ripplet (Juliet et al., 2016) has been identified to achieve the directionality and scalability features

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