

3D Improve Zero Memory Set Partitioned Embedded BloCK Coding Algorithm for Hyperspectral Image

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Abstract—Hyperspectral imaging maintain a crucial role for the remote sensing technologies. But, the amount of image data produce by the image sensors is huge, thus handling of this image data become an issue with the sensor and it's performance. A compression algorithm is required to save the sensor memory, reduce data complexity and improves sensor performance. In past, many compression algorithms had been proposed but transform based compression algorithms performed better than other type of compression algorithms such as embeddedness, high coding efficiency and low coding complexity. Wavelet transform based compression algorithm has low coding memory and 3D Zero Memory Set Partitioned Embedded bloCK (3D-ZM-SPECK) achieve zero coding memory but has slightly low coding efficiency. To obtain higher coding efficiency, present compression algorithm is an advance version of 3D-ZM-SPECK which exploits spectral redundancy to achieve the high coding efficiency. It has been noticed from the simulation results on two different images that present compression algorithm high coding efficiency (~4% to 5%) and zero coding memory requirement.

Keywords—Compression, Wireless Sensor, Energy Efficient, Transform Coding, Set Partitioned

I. INTRODUCTION

The rapid advancement of remote sensing imaging technology has precipitated a significant increase in both the spatial and spectral resolution of HyperSpectral (HS) images, enabling the convenient acquisition of data comprising hundreds to thousands of spectral bands [1]. The HS image data carries the valuable weather of information which is essential to numerous applications including precision agriculture, biomedical, township planning, target detection, and military reconnaissance [2]. But, this immense image data presents a formidable challenge to the performance of the associated image sensor including challenges associated to the data transmission bandwidth, energy consumption, associated battery life and memory storage [3]. Consequently, it is required to implement a competent image compression algorithm for HS image before the processing of HS image. The selection of compression algorithm is depended on the type of application. It is depending on weather preserving of HS image data is required (lossless compression) or some inadequate image data loss can be entertained (lossy compression) [4].

Hyperspectral image compression algorithms are fundamentally divided into two groups named as lossless and lossy compression algorithms. While lossless compression algorithms guarantee the complete restoration of the original HS image data while maintaining a low compression ratio of

~3 [5]. Given the substantial spectral and spatial redundancies inherent in the HS image data, this entropy ceiling presents a significant bottleneck for efficient storage and transmission. With this, lossy compression algorithms have emerged as a good alternative, which strategically discards perceptually or analytically less critical HS image information to achieve substantially higher compression ratios, often ranging the compression ratio from 15 to 100 [6]. Although this approach introduces a degree of distortion, empirical evidence suggests that the judicious removal of redundant data can not only alleviate data handling burdens without critically compromising subsequent analytical [7].

In the last couple of decades, many compression algorithms for the lossy compression had developed by the researchers designed to manage the unique HS image data characteristics. These traditional methodologies can be broadly categorized into three principal theoretical frameworks [8]. The first, mathematical transform based approaches, leverage mathematical tools such as the Discrete Cosine Transform (DCT) or Wavelet Transform to decorrelate the strong spectral and spatial redundancies present in the HS image, concentrating image energy into a few coefficients that can be efficiently quantized and encoded. The second class, vector quantization (VQ), operates by mapping blocks (cubes) of HS image pixels or entire spectral vectors from a high-dimensional space directly into a predefined codebook, achieving compression by transmitting only the indices of the closest matching codebook entries [9]. Finally, algorithms grounded in sparse representation theory exploit the inherent low-dimensional structure of hyperspectral data, positing that any spectral signature can be represented as a linear combination of a few coefficients from a learned or analytical dictionary, thereby enabling compression through the storage of only the sparse coefficient vectors. Each of these foundational paradigms has laid the critical groundwork for the sophisticated compression techniques in use today [10].

II. RELATED WORK

In past different compression algorithms based on the mathematical transform had been proposed which shows the better performance with the other type of compression algorithms [11]. Set Partition Based Compression Algorithms are a one sub type of mathematical transform-based compression algorithms which utilized the properties of the wavelet transform to achieve compression of the HS image [12]. This type of compression algorithm has high coding efficiency, embeddedness (decoding achieve at the low bit rate than encoding rate), low coding memory and reasonable coding complexity [13]. Choice of the compression algorithm