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Analysis of Hyper Spectral Image and Compression Algorithm Parameters

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Abstract

Hyper Spectral imaging is similar to spectral imaging where information is collected and processed across the electromagnetic spectrum. Information's are retrieved in the form of images/bands. Since images are collected across the electromagnetic spectrum, there will be correlation existing in the image data cube that has been formed. CCSDS (Consultative Committee for Space Data Systems) has proposed a method to compress these huge sized hyper spectral images. The main focus of this paper is to analyze the correlation that exists in the image and to analyze the compression parameters.

Keywords Hyper Spectral Images, lossless compression, adaptive prediction, Spatial and Spectral Correlation.

Introduction

Hyper spectral imaging is widely being researched in recent years due to its wide-spread applications in areas such as meteorology, mineralogy, ecology etc. Every information related to the applications under concern is collected by the hyper spectral sensor as a set of 'images'. Every pixel in an image records the intensity of light falling on it from across the electromagnetic spectrum. Each image is also known as a spectral band. These 'images'/spectral bands are then combined to form a three-dimensional hyper spectral data cube for processing and analysis.

Compression of Image can be performed using lossy or lossless compression schemes. Since hyper spectral images are meant for analysis purpose, focus in this paper is on the analysis of the CCSDS proposed lossless compression algorithm.

Current hyper spectral image compression schemes can be classified by the techniques used to explore data correlations. These include vector quantization (VQ), transform coding, Predictive Coding etc. VQ based approach [1, 2] partition hyper spectral bands into blocks and co-located pixels (pixels with the same spatial location in each band) within the block are set to form a vector. VQ indexes and prediction residuals are compressed using entropy coding.

Transform based schemes largely follow the framework of 3-D image/video compression and treat spatial and spectral data correlations indiscriminately. The goal is to jointly explore the spectral and the spatial data correlations. In [3], an integer wavelet packet transform (WPT) was adopted. The coding schemes were 3-D Embedded Zero Block Coding (3-DEZBC) plus context based adaptive arithmetic coding. The scheme reported in [4] uses a hybrid 3-D wavelet transform plus context based adaptive arithmetic coding (CBAAC). The discrete cosine transforms (DCT) and the Karhunen-Loeve transform (KLT) have also been employed in the literature [5].

In this paper, Correlation analysis is performed on images and also performance analysis of CCSDS proposed lossless hyper spectral image compression scheme is performed based on input parameters to the algorithm.

Correlation Analysis

Compression relies on the statistical structure in the data. There are two types of correlation in hyper spectral image. They are spatial correlation and spectral correlation. Spatial correlation is between adjacent pixels in the same band, and spectral correlation is between pixels in adjacent bands. These correlations are exploited in compressing the hyper spectral images to a great extent. Higher the correlation better is the compression algorithm performance. Pixel intensity values for various bands were plotted and it can be seen that there exists correlation in the hyper spectral image.

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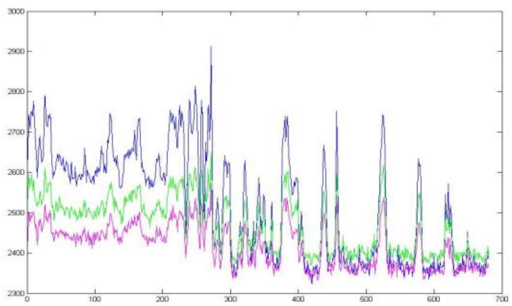

Figure 1: Pixel intensity values of Band 222, 223, 224

CCSDS Proposed Algorithm for Hyper Spectral Image Prediction and Encoding

CCSDS proposed algorithm has the below steps for the compression as described in [6]:

Step 1: Compute Local Sum for the input sample to be predicted.

Step 2: Compute the local difference of the input sample under prediction.

Step 3: Estimate the weight values for adaptive prediction.

Step 4: Compute the predicted sample.

Step 5 : Encode the predicted sample using sample adaptive encoding or Block adaptive encoding.

Analysis of the CCSDS Proposed Algorithm for Various Parameters

Parameter 1: Prediction Depth P

Prediction depth P is a user defined parameter taking values between 1 and 16. Prediction depth with a value 1 indicates that one spectral band is taken for the prediction of a sample where as prediction depth with a value of 16 which is maximum value indicates that 16 adjacent bands are taken for the second order prediction of a sample. Hence performance of the compression algorithm can be verified by changing the values of the Prediction depth. Sample Image chosen is AVIRIS sc0_raw for the analysis. When the prediction depth is 1, compression rate of 6.28 is achieved, when the prediction depth is increased and the same image is given for compression, a compression rate is reduced indicating a better performance. Thus for a AVIRIS instrument images, higher of values of prediction depth provides a better compression. This is substantiated by the graph given below.

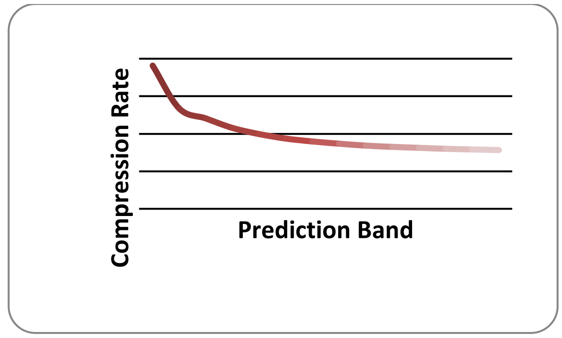

Figure 2: Plot between Compression Rate Versus Prediction Band

Parameter 2: Weight Update factor tinc

Weight update factor is one of the important parameter that determines the performance of CCSDS compression algorithm. Weight update factor is a power of 2 and in the range $2^4 \leq$ tinc $\leq 2^{11}$. When Simulated with AVIRIS images as inputs and varying tinc values, it was seen that higher the values of tinc, better is the compression rate. Figure show that when the tinc values were varied from 16 to 2048, compression rate decreased from 6.33 to 6.055 providing a better compression rate at the higher values of tinc.

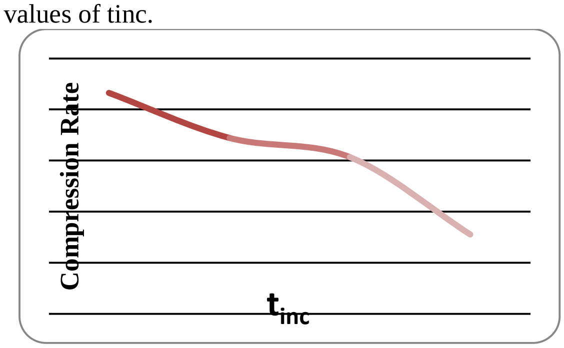

Figure 3: Plot between Compression Rate and t-increment

Conclusion

From the results obtained, it can be seen that correlation existing in hyper spectral images can be exploited in compression of the large sized images. User defines values such as Prediction depth (P), Weight update factor (tinc) determine the performance of the compression algorithm during the prediction stage.

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