ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 5, Issue 5, May 2016**

# Lossless Iterative Compression for HSI Using Combined LDA Feature and Channel Coding

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**ABSTRACT:** Hyper spectral images provide a more detailed information than multispectral images, as every pixel in the image contains contiguous spectral bands to characterize the details in the scene. Since hyper spectral images occupy large memory space and take more processing time for the transmission, it is highly desirable to use an efficient compression technique. The technique is proposed with feature based on HSI image compression using LDA. The implementation of Linear Discrimanant Analysis (LDA) as spectral decorrelator and wavelet transformation as spatial decorrelator. LDA estimates the number of principal component and eigen value as the metric to allocate the storage and Correlation Coefficient (CC) is estimated based on the CC, the threshold computation.The bands are segregated into high correlation bands and low correlation bands. Now an efficient HSI compression approach is introduced based on Discrete Wavelet Transform (DWT) for the initial band of HIS and it exploits the information of both spectral and spatial in the images. The compressed output is decoded and reconstructed accordingly.Thus, LDA reducing the spectral redundancy of images, it leaves the spatial redundancy unchanged, which is to be handled with a specialized spatial-compression method independently, and it is proved to be highly efficient.The results will indicate that hyper spectral image compression based on non-iterative method of matrix factorization with less processing time, compared with compression based on Tucker decomposition.

**KEYWORDS**: Compression, discriminant information, feature images, hyperspectral images, principal component analysis (PCA), residual images.

## I. INTRODUCTION

The advancement of sensor technology produces remotely sensed data that have a large number of spectral bands. There is an increasing need for efficient compression techniques for these hyperspectral images. Many researchers have studied lossless and lossy compression techniques, where the latter can achieve higher compression ratios than the former. Since adjacent bands of hyperspectral data are highly correlated, most compression techniques use this property to remove spectral redundancy: most lossless techniques resort to prediction, whereas most lossy techniques resort to transform-based approaches. In particular, in transform-based methods, principal component analysis (PCA) [also known as Karhunen–Loève transform (KLT)] has been commonly used, often followed by 2-D transforms such as the discrete wavelet transform (DWT) or the discrete cosine transform (DCT). Wavelet transform-based methods have drawn great interest, too, and a number of 2-D waveletbased techniques have been extended to 3-D applications, including set partitioning in hierarchical trees (SPIHT), set partitioning embedded block (SPECK), and tarp coding.

In addition, JPEG2000 standard (Annex I, Part 2) allows compressing hyperspectral images with arbitrary spectral decorrelation. Region-based coding schemes have been studied, too, often yielding improved SNR performance. Most lossy compression methods have been developed to minimize mean squared errors between the original and the reconstructed pixels. However, discriminant information required to distinguish between the various classes is also vital for classification purposes applications. As an example, JPEG2000 coders coupled with spectral PCA produce good performance in terms of SNR, but their classification accuracy may not be satisfactory since they may not effectively preserve the discriminant features for classification, mostly because these features may not be large in terms of energy. In this letter, we propose a hybrid compression method that takes into account the discriminating information of hyperspectral images. First, we apply a feature extraction method to obtain feature images, which are then used to generate featurereconstructed images. These feature-reconstructed images are subtracted from the original images to produce residual images. The feature images and some eigenimages of the residual images are compressed using conventional compression techniques.

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## II. RELATED WORK

1.Hyper-Spectral Image Analysis With Partially Latent Regression and Spatial Markov Dependencies In 2015, Antoine Deleforge, Florence Forbes, Siléye Ba, and Radu Horaud employed Hypers pectral datac an be analyzed to recover physical properties at largePlanetary scales.This involves resolving in verse problems which can be addressed within machine learning,with the advantage that,on relationship between physical parameters and spectra has been established in a data driven fashion,

The learned relationship can be used to estimate physical parameters for new hyper spectral observations.Within this framework,spatially constrained and partially latent regression method which maps high-dimensional inputs hyper spectral images on to low dimensional responses physical parameters such as the local chemical composition of the oil.The proposed regression model comprises two key features. First, it combines a Gaussian mixture of locally linear mappings (GLLiM) with a partially latent response model.While the high-dimensional regression tractable,the latter enables to deal with physical parameters that cannot be observed or, more generally,with data contaminated by experimental artifacts that cannot be explained with noise models. Second, spatial constraints are introduced in the model through a Markov random field (MRF) prior which provides a spatial structure to the Gaussian mixture hidden variables.Experiments conducted on a database composed of remotely sensed observations collected from the Mars planet by the Mars Expressor biter demonstrate the effectiveness.

2.Lossless Compression of Hyperspectral Imagery via Clustered Differential Pulse Code Modulation with Removal of Local Spectral Outliers

In 2015, Jiaji Wu, Wanqiu Kong, Jarno Mielikainen, and Bormin Huang employed A high-order clustered differential pulse code modulation method with removal of local spectral outliers(C-DPCM-RLSO) is proposed forthe lossless compression of

hyperspectral images. By adaptively removing the local spectral outliers, the C-DPCM-RLSO method improves the prediction naccuracy of the high-order regression predictor and reduces the residuals between the predicted and the original images. The experiment on a set of the NASA Airborne Visible Infrared Imaging Spectrometer(AVIRIS)test images show that the C-DPCM-RLSO method has a comparable average compression gain but a much reduced execution time as compared with the previous lossless methods. While hyperspectral images possess rich spatial and spectral information, the huge amount of data generated from a hypers pectral imager, such as the Airborne Visible Infrared Imaging Spectrometer(AVIRIS),poses a challenge to data transmission and storage.

3. A Novel Rate Control Algorithm for Onboard Predictive Coding of Multispectral and Hyperspectral Images

In 2014, Diego Valsesia and Enrico Magli employed Predictive coding is attractive for compression on board of spacecraft due to its low computational complexity,modest memory requirements, and the ability to accurately control quality on a pixel-by-pixel basis. Traditionally, predictivecompression focused on the lossless and near-lossless modes of operation, where the maximum error can be bounded but the rateof the compressed image is variable. Rate control is considereda challenging problem for predictive encoders due to the dependencies between quantization and prediction in the feedback loop and the lack of a signal representation that packs the signal's energy into few coefficients. In this paper, we show that it is possible to design a rate control scheme intended for onboard implementation. In particular, we propose a general framework to select quantizers in each spatial and spectral region of an image to achieve the desired target rate while minimizing distortion. The rate control algorithm allows achieving lossy near-lossless compression and any in-between type of compression, e.g., lossy compression with a near-lossless constraint. While this framework is independent of the specific predictor used, in order to show its performance, in this paper, we tailor it to the predictor adopted by the CCSDS-123 lossless compression standard,obtaining an extension that allows performing lossless, near-lossless, and lossycompression in a single package. We show that the rate controller has excellent performance in terms of accuracy in the output rate, rate–distortion characteristics, and is extremely competitive with respect to state-of-the-art transform coding.

4.Lossless to Lossy Dual-TreeBEZW Compression for Hyperspectral Images

In 2014, Kai-jen Cheng and Jeffrey Dill employed lossless to lossy compression scheme for hyperspectral images based on dual-tree Binary Embedded Zerotree Wavelet (BEZW) algorithm. The algorithm adapts Karhunen–Loève Transform and Discrete Wavelet Trans- form to achieve 3-D integer reversible hybrid transform and decorrelate spectral and spatial data. Since statistics of the hyper-spectral image are not symmetrical, the asymmetrical dual-tree structure is introduced. The 3-D BEZW algorithm compresses hyperspectral images by implementing progressive

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(An ISO 3297: 2007 Certified Organization)

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bitplane coding.The lossless and lossy compression performance is compared with other state-of-the-art predictive coding and transform-based coding algorithms on Airborne Visible/Infrared Imaging Spectrometer images. Results show that the 3-D-BEZW lossless compression performance is comparable with the best predictive algorithms, while its computational cost is comparable with those of transform based algorithms.

5. Adaptive Hyperspectral Image Compression using the KLT and Integer KLT Algorithms

In 2014, Chafik Egho and Tanya Vladimirova employed the Karhunen-Loéve Transform(KLT) for spectral decorrelation in compression of hyperspectral satellite images results in improvedperformance. However, the KLT algorithm consists of sequential processes, which are computationally intensive,such as the covariance matrix computation, eigenvector evaluation and matrix multiplications. These processesslow down the overall computation of the KLT transformsignificantly. The traditional KLT can only offer lossycompression; therefore, a reversible KLT algorithm,named the Integer KLT, is used for lossless compression.The Integer KLT includes more computational processes and, hence, it requires a longer processing time. The acceleration of these processes within the context of limitedpower and hardware budgets is the main objective of thispaper. The computations of each of these processes areinvestigated thoroughly. Subsequently, a novel adaptivearchitecture for the computation of the KLT and theInteger KLT is proposed. The proposed system improvesthe traditional KLT performance compared with aprevious architecture, and offers significant improvement for hyperspectral data with a larger spectral dimension.The experiments showed an overall improvement of up to4.9%, 11.8% and 18.4% for 8, 16 and 32 spectral bands,respectively. In addition, this paper addresses novelhardware aspects of the Integer KLT implementation.

6.Compression of Hyperspectral Images Containing a Subpixel Target

In 2014,Merav Huber-Lerner, Ofer Hadar, Stanley R. Rotman and Revital Huber-Shale employed Hyperspectral (HS) image sensors measure the reflectance of each pixel at a large number of narrow spectral bands, creating a three-dimensional representation of the captured scene. The HS image (HSI) consumes a great amount of storage space and transmission time. Hence, it would be desirable to reduce the image representation to the extent possible using a compression method appropriate to the usage and processing of the image. Many compression methods have been proposed aiming at different applications and fields. This research focuses on the lossy compression of images that contain subpixel targets. This target type requires minimum compression loss over the spatial dimension in order to preserve the target, and the maximum possible spectral compression that would still enable target detection. For this target type, we propose the PCA-DCT (principle component analysis followed by the discrete cosine transform) compression method. It combines the PCA's ability to extract the background from a small number of components, with the individual spectral compression of each pixel of the residual image, obtained by excluding the background from the HSI, using quantized DCT coefficients. The compression method is kept simple for fast processing and implementation,and considers lossy compression only on the spectralaxis. The spectral compression achieves a compression ratio of over 20. The popular Reed-Xiaoli (RX) algorithm and the improvedquasi-local RX ( ) are used as target detection methods. Thedetection performance is evaluated using receiver operating characteristics (ROC) curve generation. The proposed compression method achieves maintained and enhanced detection performance,compared to the detection performance of the original image, mainly due to its inherent smoothing and noise reduction effects.

7. Spectral compression of hyperspectral images by means of nonlinear principal component analysis decorrelation

In 2014 G. A. Licciardi, J. Chanussot and A. Piscini employed Transform-based lossy compression has a huge potential for hyperspectral (HS) data reduction. The emerging JPEG2000 technology is based on the synergistic use of both spectral and spatial compression techniques. In this context the choice of the spectral decorrelation approach can have a strong impact on the quality of the compressed image. Since hyperspectral images are highly correlated within each spectral band and in particular across neighboring frequency bands, the choice of a spectral decorrelation method that allows to retain as much information content as possible is desirable. From this point of view, several methods based on PCA and Wavelet havebeen presented in the literature. In this paper, we propose the use of Nonlinear Principal Component Analysis (NLPCA) transform as a lossy spectral compression method applied tohyperspectral data. Being the NLPCA the nonlinear generalization of the standard principal component analysis (PCA), it permits to represent in a lower dimensional space the same information content with less features than the standard PCA

8. Group and Region Based Parallel Compression Method Using Signal Subspace Projection and Band Clustering for Hyperspectral Imagery

In 2011, Lena Chang, Yang-Lang Chang, Z. S. Tang, and Bormin Huang,employed a novel group and region based parallel compression approach is proposed for hyperspectral imagery. The proposed approach contains two algorithms,

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

which are clustering signal subspace projection (CSSP) and the maximum correlation band clustering (MCBC). The CSSP first divides the image into proper regions by transforming the high dimensional image data into one dimensional projection length. The MCBC partitions the spectral bands into several groups according to their associated band correlation for each image region.

The image data with high degree correlations in spatial/spectral domains are then gathered in groups. Then, the grouped image data is further compressed by Principal Components Analysis (PCA)-based spectral/spatial hyper-spectral image compression techniques. Furthermore, to accelerate the computing efficiency.

We present a parallel architecture of the proposed compression approach by using parallel cluster computing techniques. Simulation results performed on AVIRIS images have shown that the proposed group and region based approach performs better than standard 3D hyperspectralimage compression. Moreover, the proposed approach achieves better computation efficiency than the direct combination of PCA and JPEG2000 under the same compression ratio.

9. On the Impact of Lossy Compression on Hyperspectral Image Classification and Unmixing

In 2011,Fernando, Garcia-Vilchez, Jordi Muñoz-Mari, MacielZortea employed Hyperspectral data lossy compression has not yet achieved global acceptance in the remote sensing community,

Mainlybecause it is generally perceived that using compressed images may affect the results of posterior processing stages. This possible negative effect, however, has not been accurately characterized so far. In this letter, we quantify the impact of lossy compression on two standard approaches for hyperspectral data exploitation: spectral unmixing, and supervised classification using support vector machines. Our experimental assessment reveals that different stages of the linear spectral unmixing chain exhibit different sensitivities to lossy data compression. We have also observed that, for certain compression techniques, a higher compression ratio may lead to more accurate classification results. Even though these results may seem counterintuitive, this work explains these observations in light of the spatial regularization and/or whitening that most compression techniques perform and further provides recommendations on best practices when applying lossy compression prior to hyperspectral data classification and/or unmixing.

## III. PROPOSED SCHEME

The image compression based on principal component analysis (PCA) provides good compression efficiency for hyperspectral images. However, PCA might fail to capture all the discriminant information of hyperspectral images, since features that are important for classification tasks may not be high in signal energy. To deal with this problem, we propose a hybrid compression method for hyperspectral images with pre-encoding discriminant information. A feature extraction method is first applied to the original images, producing a set of feature vectors that are used to generate feature images and then residual images by subtracting the feature-reconstructed images from the original ones. Both feature images and residual images are compressed and transmitted. Experiments on data from the Airborne Visible/Infrared Imaging Spectrometer sensor indicate that the proposed method provides better compression efficiency with improved classification accuracy than conventional compression methods.

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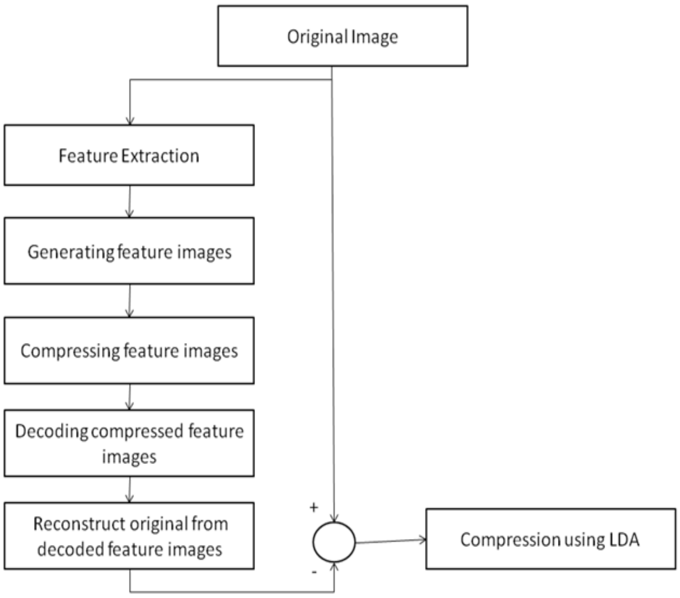


**Fig.1 LDA encoding process**

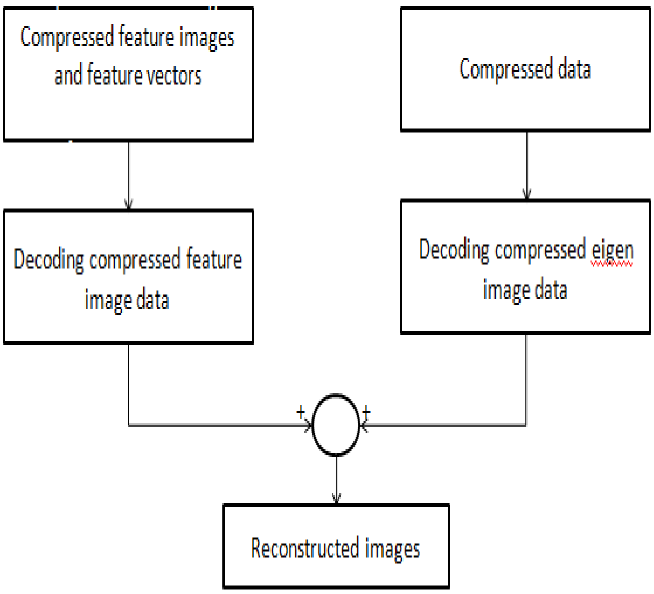


Fig.2 LDA decoding process

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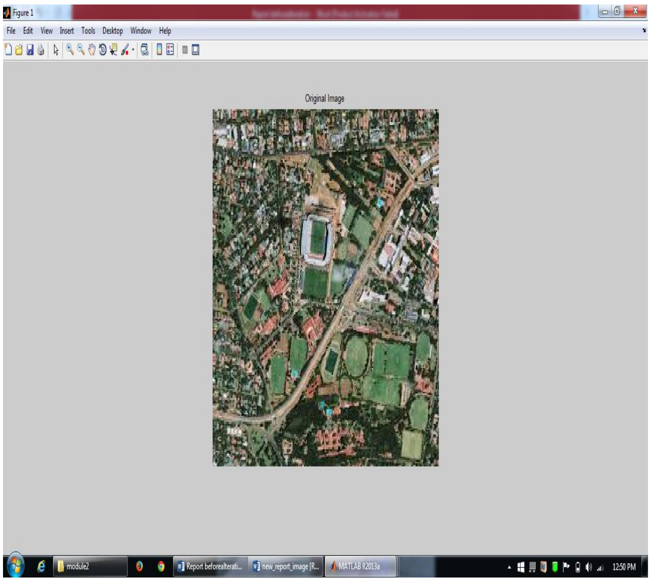
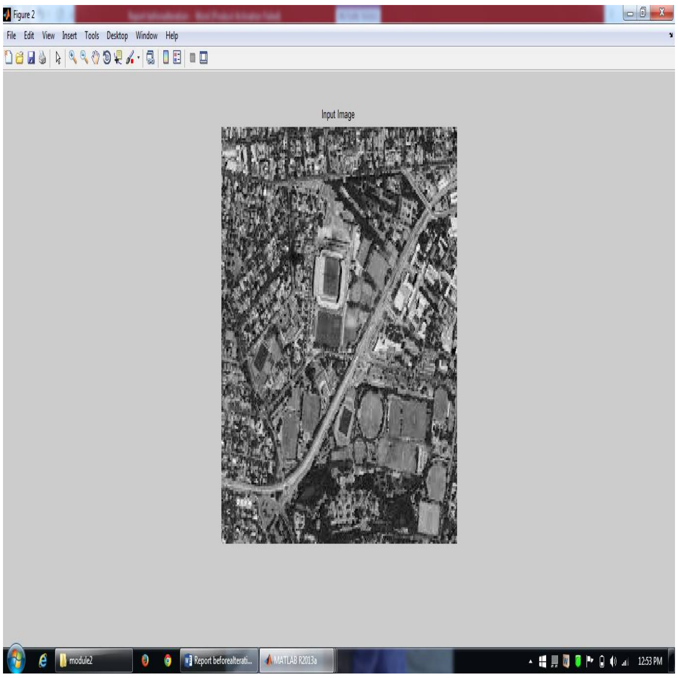
## IV. EXPERIMENTAL RESULTS




**Original Image**




**Input Image**

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ISSN (Online): 2278 – 8875

**International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering**

*(An ISO 3297: 2007 Certified Organization)*

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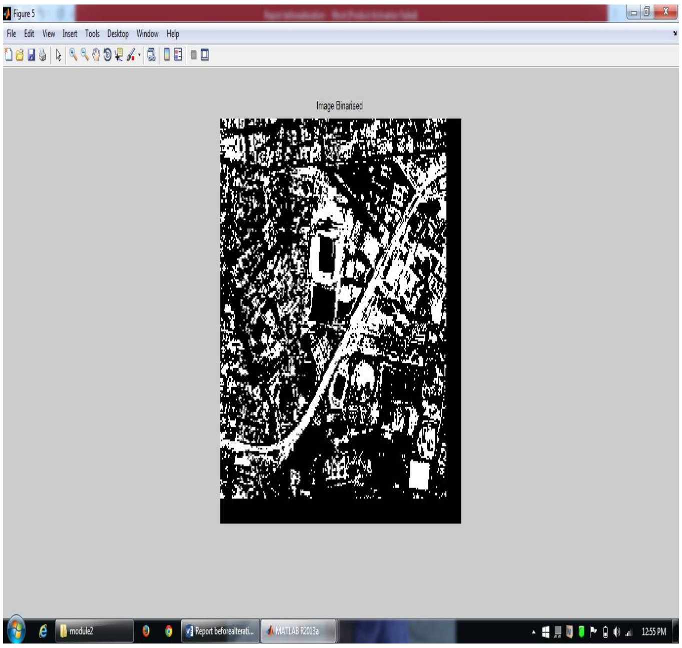
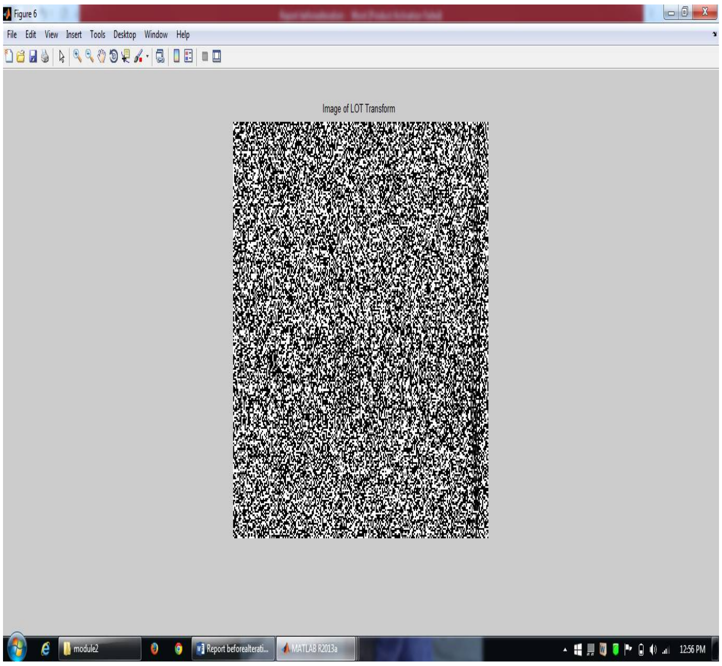



**Binarised image**




**LO Transform**

## V. CONCLUSION

In this letter, we have proposed a hybrid compression method for hyperspectral images based on PCA along with encoding residual discriminant information. We first applied a feature extraction method to obtain the feature images and then encoded the hyperspectral images using the dominant feature images. Then, we generated residual images by subtracting the reconstructed images from the original images. By applying PCA to the residual images, we generated the eigenimages, which were also encoded. The dominant eigenimages and discriminant feature images were

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ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

compressed using conventional image compression techniques to achieve better performance. Experiments with AVIRIS showed that the proposed method produces better compression efficiency with improved classification accuracy than existing compression methods such as 1-D + 2-D JPEG2000 and subPCA/1-D + 2-D JPEG2000..

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