Title: **Associate Prof., Dr**. (paper no.: 1757, access no: lena1013
Family Name: **Chang** **Given Name: Lena**
Institution: **Department of Communications and Guidance Engineering, National Taiwan Ocean University**
Address: No. 1 Baling Rd., Keelung, Taiwan, R.O.C.
Country: R.O.C. **Post Code: 100** **Phone No.: 886-2-23652680**
Fax No.: 886-2-23652680 **Email Address: lenachang@mail.ntou.edu.tw**
Presentation Preference: Interactive Technical Sessions
Abstract title: A Group and Region Based Compression Method for Hyperspectral Imagery
Name of author(s): Lena Chang, Ching-Min Cheng and Yang-Lang Chang
Corresponding author: Lena Chang

ABSTRACT

Hyperspectral imagery with hundreds of bands offers high spectral resolution and provides the potential accuracy in detection and classification of targets unresolved in multispectral images. Concerning the hyperspectral images, their accessibility is hindered by the size of image and communication bandwidth. To alleviate this limitation, it is essential to develop a high efficient compression technique for hyperspectral images.

There are various compression methods which can be mainly categorized into two families: the transform coding and the vector quantization (VQ). Compared with VQ, transform coding is adopted to achieve a good coding efficiency with limited complexity. To deal with multispectral images, [1] proposed a three-dimensional (3D) transform-based compression technique, which contains a one-dimensional Karhunen-Loeve transformation (KLT) to decorrelate the data correlation in spectral domain and a two-dimensional discrete cosine transformation (DCT) in spatial domain. In [1], a macro-block adaptive KLT approach was developed, where the image is divided into fixed blocks and for each block the local KLT transformation matrix is computed and transmitted. [2] proposed a eigen-region based KLT (ER-KLT) compression method with a variable-sized regions which are partitioned according to the local terrain characteristics of image. These compression methods [1, 2] are developed for multispectral images and the computation complexity will increase significantly for more spectral bands. Thus, it is inappropriate to directly employ these methods for hyperspectral image compression.

In this study, we develop a group and region based KLT (GR-KLT) compression technique for hyperspectral images, which exploits high degree correlations in spectral and spatial domains. The proposed method contains a clustering signal subspace projection (CSSP) segmentation method and the maximum correlation band clustering (MCBC) method [3]. In order to increase the efficiency of image compression, we propose the CSSP method, which first transforms the high-dimensional image data into low-dimensional image features by projecting the image data onto one signal subspace, and then partitions the image into proper regions according to the statistical properties of the extracted image features. Next, we applied the MCBC method to partition the frequency bands into groups according to correlation coefficient between the spectral bands for each image region. Then, the KLT transformation is performed for each group in each image region. Since the proposed GR-KLT method has fully removed the data correlations in spatial and spectral domain, it results in the high compression efficiency. Finally, to verify the feasibility and efficiency of the proposed GR-KLT compression method, we realize the method by utilizing a parallel computing architecture. Simulation results validated that the GR-KLT compression method achieves the higher compression ratio and better image quality with less computation time.

The proposed GR-KLT shown in Fig.1 is summarized as follows:

(1) Divide the original image into several eigen-regions based on the CSSP segmentation method. Let $\mathbf{x}_n$ denotes the image data corresponding to the *nth* eigen-region.

(2) Partition the spectral bands into groups for each eigen-region by using MCBC method, a band-grouping procedure. The image data $\mathbf{x}_n$ is represented as $\mathbf{x}_n = [\mathbf{x}_{n,1}, \mathbf{x}_{n,2}, \cdots, \mathbf{x}_{n,L_n}]$, where $\mathbf{x}_{n,k}$ denotes the *kth* group data of *nth* eigen-region.

(3) Extract the image feature of each group by the KLT transformation $\mathbf{z}_{n,k} = \mathbf{\Phi}_{n,k}\mathbf{x}_{n,k}$, where $\mathbf{\Phi}_{n,k}$ is composed of the principal eigenvectors of $\mathbf{R}_{n,k} = E[\mathbf{x}_{n,k}\mathbf{x}_{n,k}^{T}]$.

(4) Perform the group-based compression for each image region via the JPEG/ JPEG 2000 standard.

We have conducted the experiments on the AVIRIS images to validate the efficiency of the proposed GR-KLT and compared it with other multispectral compression algorithms: JPEG standard, KLT-JPEG [1], and ER-KLT [2]. According to the CSSP method, the AVIRIS image is partitioned into 4 regions shown in Fig.2. Simulation results in Table 1 validate that the compression ratio of the proposed GR-KLT is above 55 percent better than JPEG, KLT-JPEG and ER-KLT compression methods, when the reconstructed image quality of these methods are close. Furthermore, we implement the proposed GR-KLT method by a parallel computer. To increase the parallel efficiency, we reallocate the image bands to the computation nodes according to the image size of $\mathbf{x}_{n,k}$, as shown in Fig. 3. The execution time of the parallel computer with different computation nodes is shown in Fig. 4.

References:

[1] J. A. Saghri, A. G. Tescher, and J. T. Reagan, "Practical transform coding of multispectral imagery," IEEE Signal Processing Mag., Vol. 12, pp. 32-43, Jan 1995.

[2] Lena Chang, “Multispectral image compression using eigen-region-based segmentation,”Pattern Recognition , Vol. 37, No.6, pp.1233-1243, 2004.

[3] Lena Chang and C. M. Cheng, “An efficient hierarchical hyperspectral image classification using binary quaternion -moment-preserving thresholding technique,” proc. of IGARSS 2009.

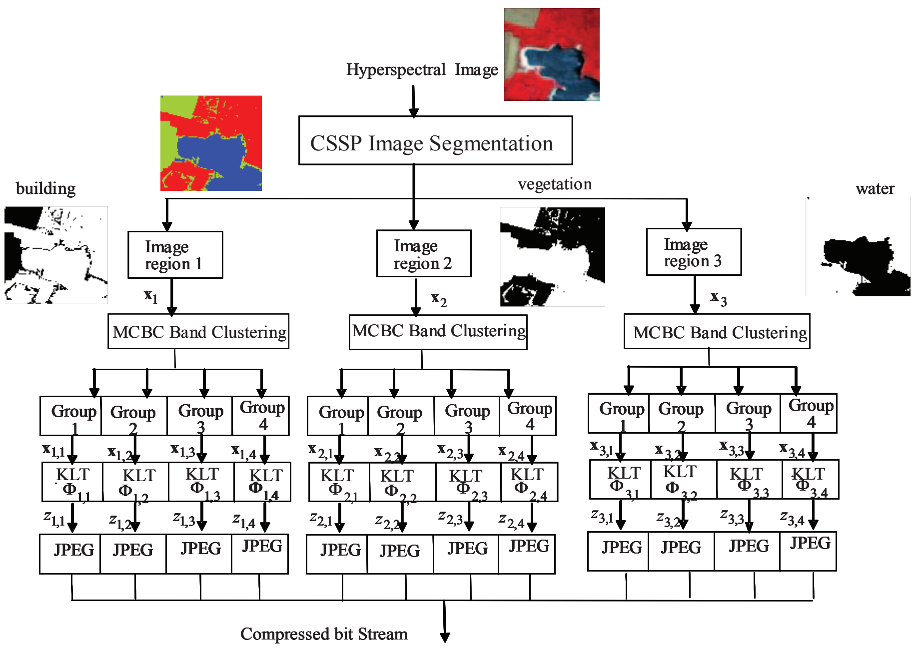
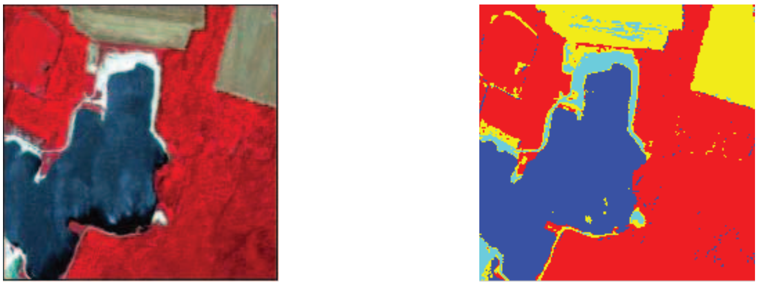


Fig. 1 Block diagram of the GR-KLT compression method



(a) original image

(b) segmentation results
(: building,
: water : vegetation)

Fig. 2 Segmentation results by the proposedCSSP

Table 1. Performance comparison

	JPEG	KLT-JPEG	ER-KLT	GR-KLT
APSNR	31.080	31.005	31.055	31.092
CR	4.955	6.282	10.498	16.369

(APSNR: average peak signal-to-noise-ratio, CR: compression ratio)

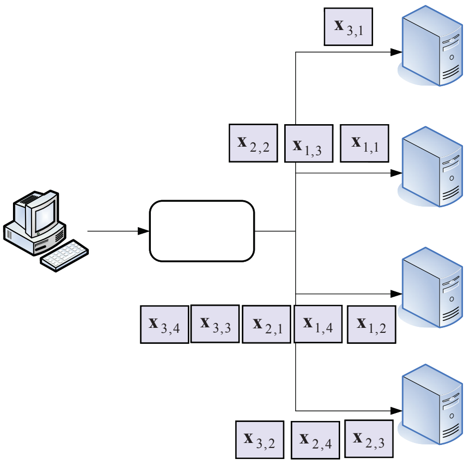


Fig.3 Image groups are allocated to computation nodes averagely

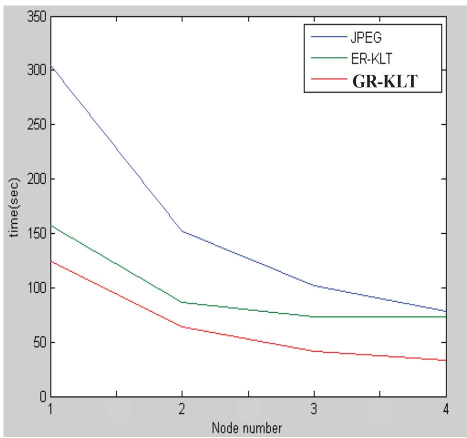


Fig. 4 Execution time of parallel computer

Autobiography

Lena Chang was born in Taipei, Taiwan, Republic of China, in 1961. She received the B.S. degree from National Tsing Hua University, in 1985, the M.S. degree from University of New Orleans, in 1987, and the Ph.D. degree from National Taiwan University, in 1992, all in Electrical Engineering. From 1987 to 1988, she worked as an Electrical Engineerin the department of R&D, ADI corp., Taipei. From 1992 to 2002, she was an Associate Professor in the Department of Merchant Marine at National Taiwan Ocean University. Since 2002, she has been an Associate Professor in the Department of Communications and Guidance Engineering, at National Taiwan Ocean University. Her research interests are in the areas of image processing, adaptive arrays and adaptive signal processing. Since 2004, she has attended the Conference of IGARSS and published papers which are listed as the following.

1. Lena Chang, C. M. Chen and J. D. Chen, 2004, “A Novel Segmentation Technique Using Eigen Space Projection for Satellite Image Indexing,” Proc. 2004 IEEE International Geoscience and Remote Sensing Symposium (IGARSS’2004), Alaska, U.S.A.
2. Lena Chang, C. M. Chen and J. C. Tang,” An Automatic Detection of Oil Spills in SAR Images by Using Image Segmentation Approach,” Proc. 2005 IEEE International Geoscience and Remote Sensing Symposium (IGARSS’2005), Seoul, Korea.
3. Lena Chang, Ching-Min Cheng and F. W. Tseng , ”A Combined Signal Subspace Projection and Partial Filtering Approach to Target Detection for Hyperspectral images,” Proc. 2006 IEEE International Geoscience and Remote Sensing Symposium (IGARSS’2006), Colorado, U.S.A.
4. Lena Chang, Ching-Min Cheng and Fu-Chuan Ni , 2007, “Adaptive Filtering Approaches for Multispectral Image Classification Based on Eigen-feature,” Proc. 2007 IEEE International Geoscience and Remote Sensing Symposium (IGARSS’2007), Barcelona, Spain.
5. Yang-Lang Chang, Lena Chang, Jyh-Perng Fang, Kun-Shan Chen, “Multisource image classification based on parallel minimum classification error learning,” Proc. 2008 IEEE International Geoscience and Remote Sensing Symposium (IGARSS’2008), Boston, U.S.A.
6. Lena Chang, Ching-Min Cheng and Yang-Lang Chang, “An Efficient Hierarchical Hyperspectral Image Classification Using Binary Quaternion-Moment-Preserving Thresholding Technique,” Proc. 2009 IEEE International Geoscience and Remote Sensing Symposium (IGARSS’2009), Cape Town, South Africa.