Change Detection in Hyper Spectral Images

Waseem Ahmad Khanday

Electronics & Communications, MVVEC, Jagadhari,
Kurukshetra University
khandaywasim@gmail.com

Kamal Kumar

kamalkhajuri277@gmail.com
Electronics & Communications, MVVEC,
Jagadhari, Kurukshetra University

Abstract- Remote **sensing change detection has played an important role in many applications. Most traditional change detection methods deal with single-band or multispectral remote sensing images. Hyperspectral remote sensing images offer more detailed information on spectral changes so as to present promising change detection performance. The challenge is how to take advantage of the spectral information at such a high dimension. Change detection is the process of identifying difference in the scenes of an object or a phenomenon, by observing the same geographic region at different times. Many algorithms have been applied to monitor various environmental changes. Examples of these algorithms are difference image, ratio image, classification comparison, and change vector analysis. In this thesis, a change detection approach for multi-temporal multi-spectral remote sensing images, based on Independent Component Analysis (ICA), is proposed. The environmental changes can be detected in reduced second and higher-order dependencies in multi-temporal remote sensing images by ICA algorithm. This can remove the correlation among multi-temporal images without any prior knowledge about change areas. Different kinds of land cover changes are obtained in these independent source images. The experimental results in real multi-temporal multi-spectral images show the effectiveness of this change detection approach.**

Keywords: Hyperspectral images, multi temporal images, hyperspectral images

1. Introduction

Remote sensing change detection has played an important role in many applications. Most of traditional change detection methods deal with single-band or multispectral remote sensing images. Hyper spectral remote sensing images offer more detailed information on spectral changes so as to present promising change detection performance. The challenge is how to take advantages of the spectral information at such a high dimension. Accurate change detection of the earth's surface features is extremely important for monitoring environmental changes and resource management. Remote sensing technology provides a large-scale view of landscape over a long period of time and has been demonstrated to be an efficient method for change detection. Change detection by remote sensing has been widely used in many applications such as land-use/land-cover monitoring, urban development, ecosystem monitoring, and disaster monitoring. Traditional change detection methods have been intensively studied. However, almost all of them are based on single-band or multispectral remote sensing images. Recently, hyper spectral Images have attracted increasing attention due to the wealth of information contained and the wide range of potential applications. Hyper spectral sensors measure radiance by a large number of bands covering a wide spectral range. Although multi temporal multispectral images can show spectral changes in several bands, the spectral information Offered by multispectral data is not so elaborate. Hyper spectral imagery offers more abundant and more detailed information on spectral changes in multi temporal scenes than multispectral images, which can improve the change detection performance. Conventional change detection methods generally depend on a difference value in each individual band, such as image differencing or the image ratio. The physical meaning of the continuous spectral signatures is ignored. Comparatively, the foremost advantage of hyper spectral data is that the high-dimensional spectral information can indicate the fine spectral signatures and the physical characteristics of different materials. For hyper spectral data, the presence of real change is represented by the change of a spectral signature from one material to another material. Therefore, this is more reasonable to directly measure the difference in the spectral signatures of different materials when solving a hyper spectral change detection problem. Several kinds of methods have been proposed for hyper spectral change detection. In post-classification methods, classification maps of multitemporal hyper spectral images are compared to obtain the change detection result. Post-classification provides "from-to" change results and has been widely used; however, its accuracy is limited because pixels misclassified in one dataset will result in errors on the "from-to" change detection map, no matter whether the corresponding pixels in the other dataset are correctly classified or not. Image transformation techniques and principal component analysis (PCA) originating from multispectral methods, transform hyper spectral data into another feature space to label the changed areas. Although these methods can make use of hyper-band information, they generally do not consider the continuous spectral signatures from hyper spectral data. The third kind of hyper spectral change detection method is anomaly change detection. Anomaly detection algorithms consider anomaly changes as outliers in a difference image. Anomaly detection focuses on distinguishing unusual targets from a typical background, and this assumption confines its application in general change monitoring. Based on the above analysis of the current hyper spectral change detection methods, it is clear that we need to explore change detection algorithms by focusing on two main points. To explore the high-dimensional spectral information and the continuous spectrum, the algorithm should directly measure the difference in the signatures to define the detailed changes in different materials. At the same time, considering the practical application, the algorithm should be simple and easy to apply.

I. Difference of Hyper spectral images from multispectral images:

The "hyper" in hyper spectral means "over" as in "too many" and refers to the large number of measured wavelength bands. Hyper spectral images are spectrally over determined, which means they provide ample spectral information to identify and distinguish spectrally unique materials. Hyper spectral imagery provides the potential for more accurate and detailed information extraction than possible with any other type of remotely sensed data.

Hyper spectral systems differ from multispectral sensors because they collect information in many contiguous narrow bands (5 to 10 nm) while hyper spectral images generally contain dozens to hundreds of bands. Multispectral systems does not cover the spectrum contiguously and their bands are generally wide (70 to 400 nm). These systems usually have a dozen or fewer bands. In a hyper spectral image, a single pixel will contain information about reflectance across the entire spectral range of the sensor producing what is called a spectral signature. The spectrum obtained from one image pixel will resemble a spectrum of the same material obtained through laboratory spectroscopy permitting detailed identification of materials.

II. Applications of Hyper spectral Image analysis:

Hyper spectral imagery has been used to detect and map a wide variety of materials having characteristic reflectance spectra. For example, hyper spectral images have been

Used by geologists for mineral mapping and to detect soil properties including moisture, organic content, and salinity. Vegetation scientists have successfully used hyper spectral imagery to identify vegetation species, study plant canopy chemistry, and detect vegetation stress. Military personnel have used hyper spectral imagery to detect military vehicles under partial vegetation canopy, and other military target detection objectives such as:

a) Atmospheric Correction
b) Spectral Libraries
c) Classification and Target Identification
d) Spectral Angle Mapper (SAM)

III. Techniques used in Change Detection for hyper spectral Images:

Several kinds of methods have been proposed for hyper spectral change detection:

a) Principal component Analysis (PCA)
b) Change Vector Analysis (CVA)
c) Image Differencing
d) Image Rationing

2. RELATED WORK

Chen W. et. al (2013) In this paper, two types of additional information, i.e., spatial information in the neighbourhood of the corresponding pixel in Time , and the spectral information of undesired land-cover types, which is used to construct the background subspace for special applications. The anomalous pixels are considered as changes so that it can take advantage of the high-dimensional information and the spectral signatures in hyper spectral images, and, at the same time, is very easy to apply.

M. Ilsever C. U et. al (2012) in this paper they present a technique for detection of hyper spectral images. They used the pixel-based change detection methods such as Image differencing, automated threshold Image rationing, Change vector analysis (CVA). The basic premise in using remote sensing data for change detection is that changes in land cover must result in changes in radiance values and changes in radiance due to land cover change must be large with respect to radiance changes caused by other factors.

Turgay.C et. al (2009) the proposed paper presents a novel technique for unsupervised change detection in multitemporal satellite images using principal component analysis (PCA) and k-means clustering. The difference images are partitioned into h × h non overlapping blocks. The change detection is achieved by partitioning the feature vector space into two clusters using k-means clustering with k = 2 and then assigning each pixel to the one of the two clusters by using the minimum Euclidean distance between the pixel's feature vector and mean feature vector of clusters. The proposed algorithm is simple in computation yet effective in identifying meaningful changes which makes it suitable.

Yakoub Bazi, F.M.D et. al (2010) in this paper, the change-detection problem of unsupervised images in remote sensing is formulated as a segmentation issue where the discrimination between changed and unchanged classes in the difference image is achieved by defining a proper energy functional. In order to increase the robustness of the method to noise and to the choice of the initial contour, a multi resolution implementation, which performs an analysis between the difference images at different resolution levels, is proposed. The experimental results obtained on the basis of three different multitemporal remote sensing images acquired by low- as well as high-spatial-resolution optical remote sensing sensors suggest a clear superiority of the proposed approach compared with state-of-the-art change-detection methods.

Jin Chen, X. C et. al (2011) in this research Post classification comparison (PCC) and change vector analysis (CVA) have been widely used for land use/cover change detection using remotely sensed data. However, PCC suffers from error commutation stemmed from an image classification error, while a firm requirement of radiometric consistency in remotely sensed data is a bottleneck of CVA. This paper proposes a new method named CVA in posterior probability space (CVAPS), which analyzes the posterior probability by using CVA.

Selim Hemissi, B.S et. al (2013) explained that multitemporal hyper spectral images are gaining an ever-increasing importance revealed by the ambition of the remote sensing community to develop new generation of sensors. Therefore, multitemporal images classification and change detection issues are greatly relevant in several research topics. In this paper, we propose a novel approach for modelling the temporal variation of the reflectance response as a function of time period and wavelength; summarizing the spectral signature of hyper spectral pixels as a 3-D mesh. This approach is adopted for hyper spectral time series analysis leading to the main following contribution: an advanced form of the temporal spectral signature defining the reflectance at each pixel as a congregation of the spatial/spectral/temporal dimensions. Afterward, by formulating the temporal data set in an adequate multidimensional feature space of contextual data, an innovative processing scheme exploiting the theoretical backgrounds of 3-D surface reconstruction and matching is adopted for data interpretation.

Zhengguang. S. W et. al (2012) in this paper, A novel strategy based on a relevance vector machine (RVM) coupled with principal component analysis (PCA) is proposed for failure detection, isolation, and recovery (FDIR) of a multifunctional self-validating sensor. The working principle and the online updating algorithm of the RVM predictor are emphasized to identify and recover faults. The proposed predictor can effectively isolate multiple simultaneous faults of multifunctional sensors and accomplish failure recovery with high accuracy and good timeliness. Further, it also possesses a good ability of tracking fault-free signals with sudden changes. Failure detection is carried out by using PCA-based squared prediction error statistics. The PCA-RVM method can distinguish the normal signals with sudden changes from faulty signals. The performance of the strategy is compared with other different predictors, and it is evaluated in a real multifunctional self-validating sensor experimental system.

Diego F. P et. al (2011) In this paper, they address this challenging issue and propose a novel technique (formulated in terms of a compound decision problem) capable of identifying specific "targeted" land-cover transitions by exploiting the ground truth available only for the classes of interest at the two dates, while providing accuracies comparable to those of traditional fully supervised change-detection methods. The proposed technique relies on a partially supervised approach that jointly exploits the expectation-maximization algorithm and an iterative labelling strategy based on Markov random fields accounting for spatial and temporal correlation between the two images. Moreover, the proposed method is applicable to images acquired by different sensors (or to different sets of features) at the two investigated times. Experimental results on different multitemporal and multisensory data sets confirmed the effectiveness and the reliability of the proposed technique.

Ashish, G. S. et.al (2013) proposed that the Experiments are carried out on three-multispectral and multitemporal remote sensing images. Results of the proposed change detection scheme are compared with those of the manual-trial-and-error technique, automatic change detection scheme based on GMRF model and iterated conditional mode algorithm, a context sensitive change detection scheme based on HTNN, the GMRF model, and a graph-cut algorithm. A comparison points out that the proposed method provides more accurate change detection maps than other methods.

T. Blaschke at (2005) this paper elucidate some specific challenges to change detection of objects and incorporates GIS-functionality into images analysis. With the content of high resolution satellite imagery and airborne digital camera data approaches that include contextual information are more commonly utilized. In this paper a problem related to multitemporal object recognition are identified and a framework for image object based change detection is suggested.

Lorenzo. B. D. et. al (2000) one of the main problems related to unsupervised change detection methods based on the "difference image" lies in the lack of efficient automatic techniques for discriminating between changed and unchanged pixels in the difference image. Such discrimination is usually performed by using empirical strategies or manual trial-and-error procedures, which affect both the accuracy and the reliability of the change-detection process. To overcome such drawbacks, in this paper, they propose two automatic techniques (based on the Bayes theory) for the analysis of the difference image. One allows an automatic selection of the decision threshold that minimizes the overall change detection error probability under the assumption that pixels in the difference image are independent of one another. The other analyzes the difference image by considering the spatial-contextual information included in the neighbourhood of each pixel.

3. OBJECTIVES

The objective is to analyze the change detection in hyperspectral images. The development tool used will be MATLAB, and emphasis will be lead on the software for performing recognition. MATLAB with its image processing toolbox and high level programming methodology provides an excellent rapid application development (RAD) environment.

- To Study the various change detection techniques
- To modify the technique for change detection
- To compare the modified technique with the existing technique.

4. PROPOSED WORK

Study of Performance Analysis of an Unsupervised Change Detection Method for High Resolution Images consists of following steps:

- Preprocessing
- Image Registration
- Image differencing
- Threshold Selection
- Change map

Preprocessing involves the same image which has different pixel values at two different times but at same parameters. The block diagram of the working methodology is shown in the figure 1.

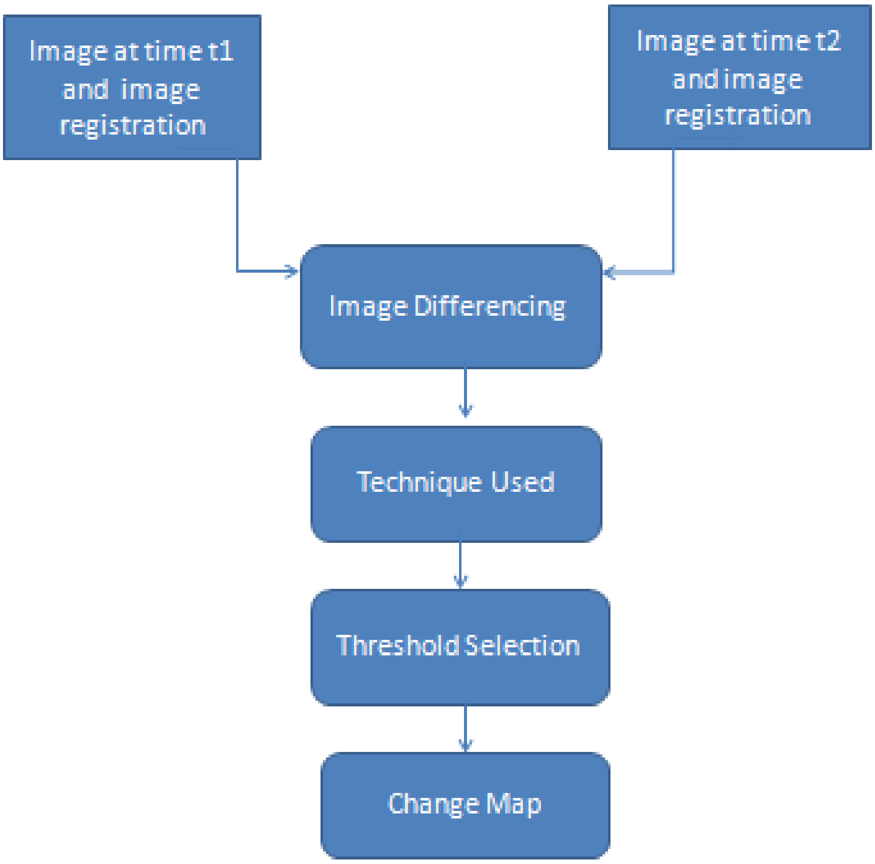

Figure 4.1: Architecture of the Proposed System.

The image is captured and given as input to the system. To determine the change detection the same image is captured at two different times. After that the image registration of the images at two times are determined by finding their pixels. Then the difference image of two satellite images acquired from the same area coverage but at two different time instances. After that the threshold values are applied to this difference image so that the extent of change can be detected. Now if the output obtained has pixel value greater than threshold value then there will be change in the difference image and vice versa.

5. Results and Discussion

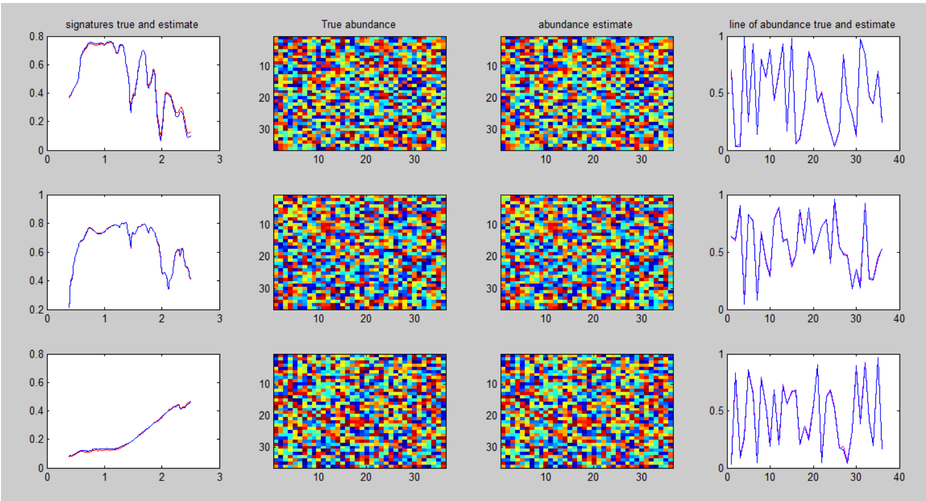

Figure 5.1 Signature true & estimate, Line of abundance true & estimate

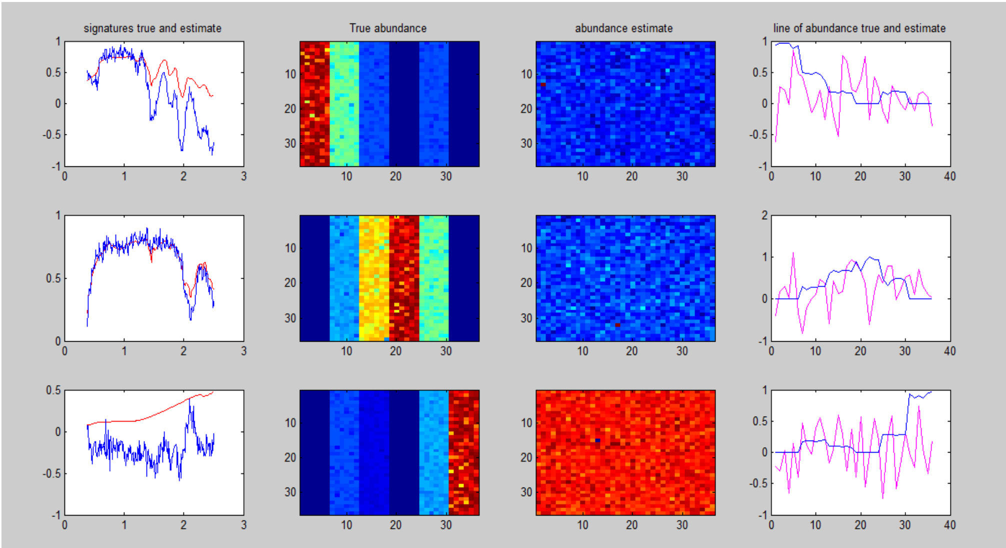

Figure 5.2 Signature true & estimate, Line of abundance true & estimate

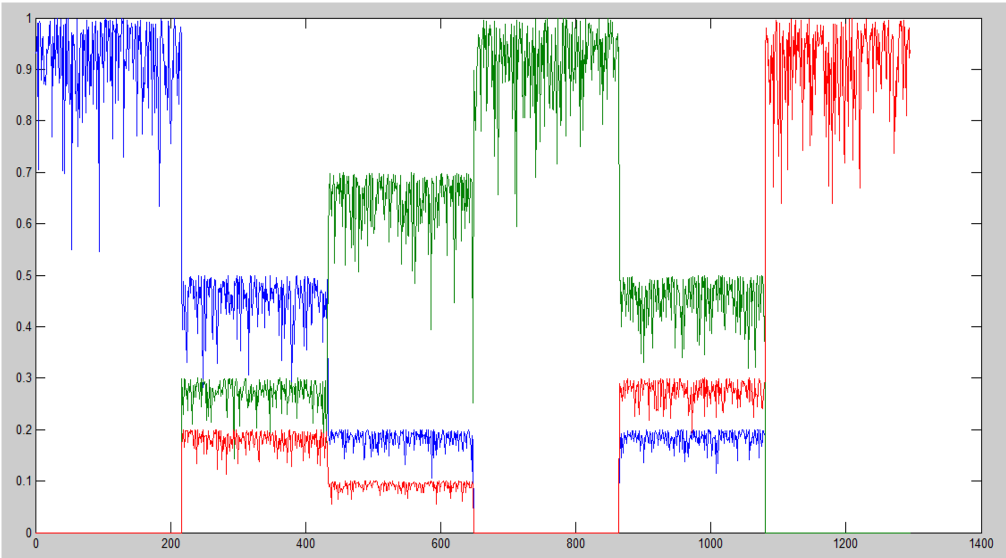

Figure 5.3 Change Map

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Carnallite NMNH98011
Ammonioalunite NMNH145596
Biotite HS28.3B
***       SNR= 29.9919dB
***       Ilumination perturbation: on
***       Signature variability: on
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6. Conclusion and Future Scope

PCA technique can provide best result for change detection by processing the two different image of same geographical area and compare both them through pixel by pixel or through principal component vector generated for both image. The PCA technique easily classifies the changed area and the unchanged area by using principal component. This PCA technique not only detect the changes in the images but also convert a very high dimension image into lower one maintaining all information related to original image. So we can easily store as it occupy less storage space as compared to original one and it is an efficient technique.

Independent component images obtained from ICA algorithm are independent of each other and they are related to different land variation classes. The synthetic and real data experiments demonstrated the combination of ICA-based image model and supervised SVM classification can make use of higher order statistics and detect changed areas efficiently and accurately from multi-temporal multi-spectral remote sensing images. Thus, ICA model is a suitable tool for improving change information extraction in multi-temporal multi-spectral images. However, the change detection scheme presented in this work only consider a relatively small number of categories and further discussion for the large number of categories and different type of noise effects will be conducted in future work.

REFERENCES

[1] Chen Wu, Bo Du, Liangpei Zhang, "A Subspace-Based Change Detection Method for Hyper spectral Images", IEEE Journal of selected topics in applied earth observations and remote sensing, vol. 6, no. 2, April 2013.

[2] M. Ilsever and C. Ünsalan,, "Pixel-Based Change Detection Methods", SpringerBriefs in Computer Science, DOI: 10.1007/978-1-4471-4255,2012

[3] Turgay Celik, "Unsupervised Change Detection in Satellite Images Using Principal Component Analysis and k-Means Clustering", IEEE Geoscience And Remote Sensing Letters, vol. 6, no. 4, october 2009

[4] Yakoub Bazi, Member, IEEE, Farid Melgani, Senior Member, IEEE, and Hamed D. Al-Sharari, "Unsupervised Change Detection in Multispectral Remotely Sensed Imagery With Level Set Methods", IEEE Transactions On Geoscience And Remote Sensing, vol. 48, no. 8, august 2010.

[5] Jin Chen, Xuehong Chen, Xihong Cui, and Jun Chen, "Change Vector Analysis in Posterior Probability Space: A New Method for Land Cover Change Detection", IEEE Geoscience And Remote Sensing Letters, vol. 8, no. 2, march 2011

[6] Selim Hemissi, Imed Riadh Farah, Karim Saheb Ettabaa, and B.Solaiman, "Multi-Spectro-Temporal Analysis of Hyper spectral Imagery Based on 3-D Spectral Modeling and Multilinear Algebra", IEEE Transactions on Geoscience and Remote Sensing, vol. 51, no. 1, january 2013

[7] Zhengguang Shen and Qi Wang,, "Failure Detection, Isolation, and Recovery of Multifunctional Self-Validating Sensor" IEEE Transactions On Instrumentation And Measurement, Vol. 61, No. 12, December 2012.

[8] Diego Fernàndez-Prieto and Mattia Marconcini, "A Novel Partially Supervised Approach to Targeted Change Detection", IEEE Transactions On Geoscience And Remote Sensing, Vol. 49, No. 12, December 2011

[9] Ashish Ghosh, B.N. Subudhi, Lorenzo Bruzzone, "Integration of Gibbs Markov Random Field and Hopfield-Type Neural Networks for Unsupervised Change Detection in Remotely Sensed Multitemporal Images", IEEE Transactions On Image Processing, Vol. 22, No. 8, August 2013

[10] Lorenzo Bruzzone, Diego Fernàndez Prieto, "Automatic Analysis of the Difference Image for Unsupervised Change Detection", IEEE Transactions On Geoscience And Remote Sensing, Vol. 38, No. 3, May 2000