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Enhancement of ICA Algorithm Using Mat lab for Change Detection in Hyper Spectral Images

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ABSTRACT

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— Hyper spectral images, Remote Sensing, FAST ICA, Change detection.

I. INTRODUCTION

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object. In modern days, the term generally refers to the use of aerial sensor technologies to detect and classify objects on Earth by means of propagated signals (e.g. electromagnetic radiation). It may be split into passive remote sensing or active remote sensing. Passive sensors gather natural radiation that is emitted or reflected by the object. Reflected sunlight is the most common source of radiation measured by passive sensors. Passive remote sensors include film infrared, photography, and radiometers. On the other hand, Active sensor emits energy in order to scan objects and areas and then detects and measures the radiation that is reflected or backscattered from the target. Best example of active remote sensing is Radar. Radar measure the time delay between emission and return, establishing the location, speed and direction of an object. Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times. Remote sensing change detection has played an important role in many applications. Many traditional change detection methods deal with single-band or multispectral remote sensing images. Timely and 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 [5]. Most hyperspectral imagers measure reflected radiation at a series of narrow and contiguous wavelength bands.Although many hyperspectral sensors measure hundreds of wavelengths, number of measured wavelengths not defines a sensor as hyperspectral until it contains the narrowness and contiguous nature of the measurements. For example, a sensor could be considered hyperspectral if it measured only 20 bands but those bands were contiguous and, say, 20 nm wide. If a sensor measured 20 wavelength bands that were say 100 nm wide or that were separated by non-measured wavelength ranges, the sensor could not considered hyperspectral.[1] Recently, Hyperspectral images have attracted increasing attention due to the wealth of information contained and the wide range of potential applications. In remote sensing (RS) applications changes are considered as surface component.

1.1 Techniques used in Change Detection for hyper spectral Images:

The principal component analysis is based on the fact that neighbouring bands of hyperspectral images are highly correlated and often convey almost the same information about the object. Principal Component

Analysis is a linear transformation technique and probably the most common of these techniques. The main leading light of the PCA approach is to use as input a set of images and to reorganize them via a linear transformation, such That the 19 output images are linearly independent. The new coordinate system for data is projected such that the greatest variance lies on the first axis or the first principal component and the second greatest variance on the second axis. This technique is generally used to decrease the number of spectral bands or in compression schemes. In CD studies, the significance of this linearization is that unchanged pixels or common information shared by a pair of images are predictable to lie in a narrow elongated cluster along a principal axis equivalent to the first component (PC1). On the contrary, pixels containing a change would be more exclusive in their spectral appearance and would be expected to lie far away from this axis (PC2) the analysis is used to transform the original data so to remove the correlation among the bands. In the process, the optimum linear combination of the original bands accounting for the variation of pixel values in an image is identified. The PCA employs the statistic properties of hyperspectral bands to examine band dependency or correlation. Though, one may find many synonyms for PCA, such as the Hotelling transformation.[6]

Recently, independent component analysis (ICA) as an extension to PCA has been proposed as a generic statistical model for images, which can be viewed as a generalization of PCA since it concerns not only with second-order dependencies but also higher-order dependencies between variables [7]. ICA is an unsupervised source separation process, which is a recently developed method for multi-channel signal processing to separate mixed signals. It has been successfully implement to blind separation problems. Through linear transformation, it reduces statistical dependency of the components of represented variables and finds a linear decomposition of observed data into independent components. ICA focuses at capturing statistical structure in images by exploiting higher-order statistical structure beyond second order information. The goal of ICA is too linearly transform the data such that the transformed variables are as statistically independent from each other as possible. It has been successfully applied in change detection for multi-temporal images. Fast Independent Component Analysis [4] is applied to the image to separate the background and the moving target. About background subtraction, the targets are detected. But there is a possibility that echoes being originated from different objects, called clutters. So, to reduce the unwanted clutter echoes, Conventional Constant False Alarm Rate detection is done. The threshold is set so that the reflected echoes above this threshold are detected as target and those below this threshold belong to background.

II. RELATED STUDY

Peg Shippert et al. [1] discuss that the most significant recent breakthrough in remote sensing has been the development of hyperspectral sensors and software to analyze the resulting image data. Fifteen years ago only spectral remote sensing experts had access to hyperspectral images or software tools to take advantage of such images. Over the past decade hyperspectral image analysis has matured into one of the most powerful and fastest growing technologies in the field of remote sensing. Hyperspectral images are spectrally overdetermined, which means that they provide ample spectral information to identify and distinguish spectrally unique materials. Hyperspectral imagery provides the potential for more accurate and detailed information extraction than possible with any other type of remotely sensed data.This paper will review some relevant spectral concepts, discuss the definition of hyperspectral versus multispectral, review some recent applications of hyperspectral image analysis, and summarize image-processing techniques commonly applied to hyperspectral imagery.

Jie Shan et al. [2] brief **t**he availability of hyperspectral images expands the capability of using image classification to study detailed characteristics of objects, but at a cost of having to deal with huge data sets. This work studies the use of the principal component analysis as a pre-processing technique for the classification of hyperspectral images. Two hyperspectral data sets, HYDICE and AVIRIS, were used for the study. A brief presentation of the principal component analysis approach is followed by an examination of the information contents of the principal component image bands, which revealed that only the first few bands contain significant information. The use of the first few principal component images can yield about 70 percent correct classification rate. This study suggests the benefit and efficiency of using the principal component analysis technique as a pre-processing step for the classification of hyperspectral images.

Masroor Hussain et al. [3] This paper begins with a discussion of the traditionally pixel-based and (mostly) statistics-oriented change detection techniques which focus mainly on the spectral values and mostly ignore the spatial context. This is succeeded by a review of object-based change detection techniques. Finally there is a brief discussion of spatial data mining techniques in image processing and change detection from remote sensing data. The merits and issues of different techniques are compared. The importance of the exponential increase in the image data volume and multiple sensors and associated challenges on the development of change detection techniques are highlighted. With the wide use of very-high-resolution (VHR) remotely sensed image object-based methods and data mining techniques may have more potential in change Detection.

S. Hanis et al. [4] discuss that a sequence of avian radar images containing the moving target is taken using an avian radar system. Radar image contains the complex background and the target (flying birds).The main objective is to detect and track the moving target using Fast Independent Component Analysis (Fast ICA) and Hough Transform. Fast ICA is used to separate the target from the background of the radar image. Constant False Alarm Rate (CFAR) segmentation determines the threshold above which the return echoes have been originated from the moving target. Clutter Suppression is done by Conventional CFAR method. Low segmentation threshold is set to avoid missed targets. Finally, the position of bird is tracked by applying hough transform.

K. Khoshelham et al. [5] author present a segment-based approach to detecting damaged building roofs in aerial laser scanning data. It consists of a segmentation step, where points are grouped into planar segments, a feature extraction step, and a classification step, where each segment is classified as damaged or intact. Such a segment-based approach faces two major challenges: first, extraction of features that are relevant to the target classes and can adequately distinguish between the intact and damaged segments is not straightforward. Second, the generation of reference segments for training and testing is difficult due the complexity of interpreting point clouds. To overcome these challenges the role of feature selection and dimensionality reduction in training a classifier using few training samples is investigated.

Vijay Kumar et al. [6] this paper proposed an approach for unsupervised change detection technique on SAR data.Change detection is process of automatically identifying and analyzing the regions which undergone some changes such as spatial or spectral changes. As various techniques are available to change detection but are used for general satellite images. In order to detect change on SAR images we use PCA technique which detect the change by finding the different pixel using threshold level and compare with earlier image one.

Juan Gu et al. [7] paper proposed 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 paper, 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 synthetic and real multi-temporal multi-spectral images show the effectiveness of this change detection approach.

III. PROPOSED WORK

From the literature, various methods have been utilized to detect the hyper spectral images. Various techniques have been used for the change detection in difference image that are acquired from the same set of two images taken at two time of instance. Since the change detection can be determined with the knowledge of pixels and vectors of the difference images for this the technique used is Change vector analysis. Also to check how much the change has occurred in the difference image from the existing one, the threshold values are set for that image. When the output of the pixel of that image is greater than the threshold value then there will be the change in difference image otherwise no change will be considered if the output of the pixel is less than threshold value. Therefore for the detection of hyper spectral images different techniques like PCA, CVA, image differencing, image rationing etc. are used so that the change can be easily detected by using hyper spectral sensors.

The objective is to analyses the change detection in hyper spectral 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.

Study of performance analysis of An Unsupervised Change Detection Method for high resolution images consists of following steps:

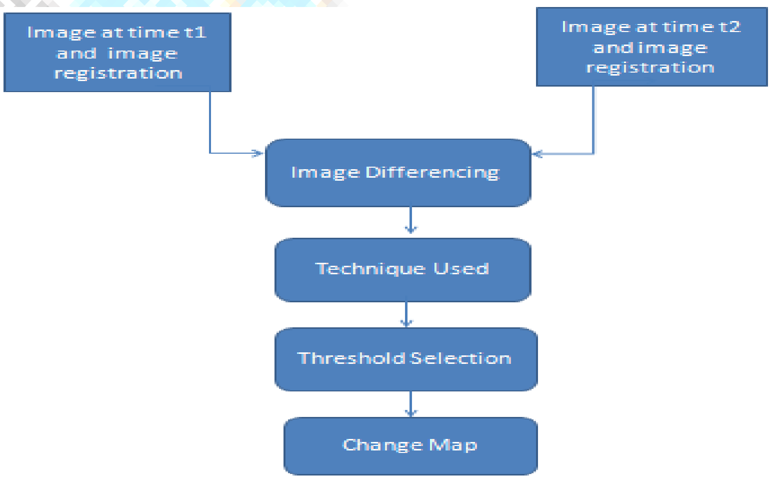


Figure1 Architecture of the Proposed System

Pre-processing involves the same image which has different pixel values at two different times but at same parameters [2]. The block diagram of the working methodology is shown in the figure 1.

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.

The ICA algorithm 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 investigation results in synthetic and real multi-temporal multi-spectral images show the effectiveness of this change detection approach.

Case 1: When Two Images are same

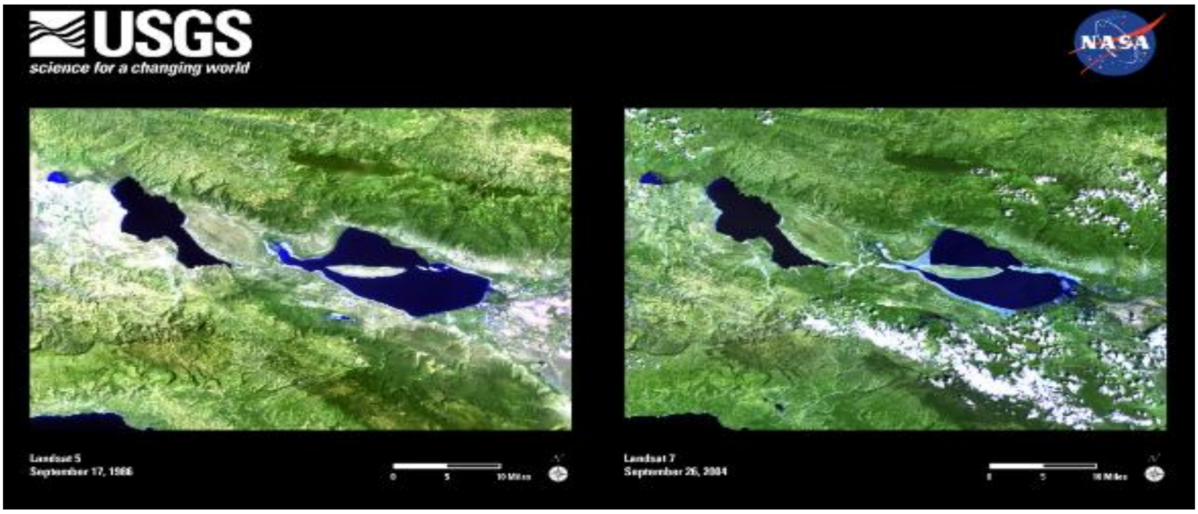


Figure 2 Input Image

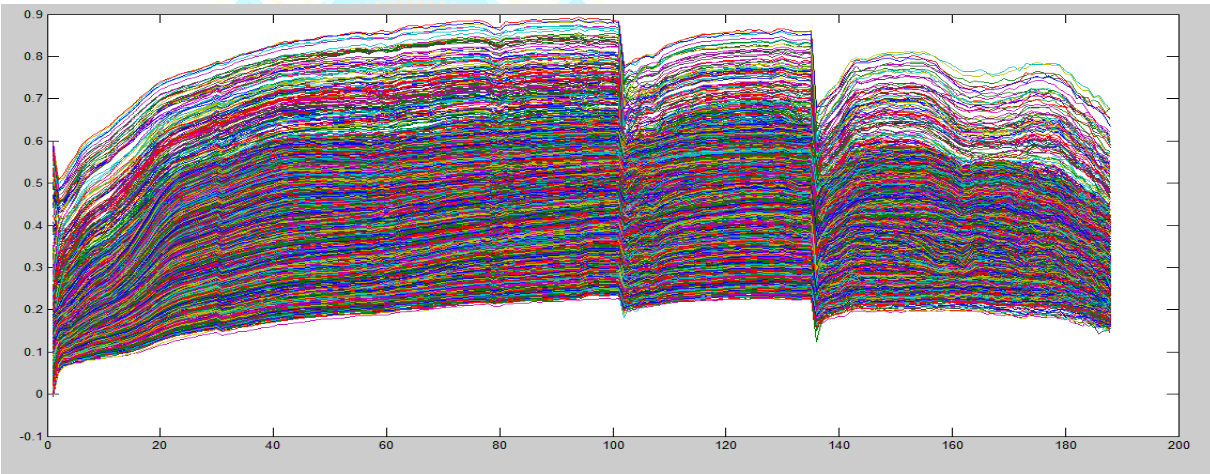


Figure 3 Pixel map of Input Image

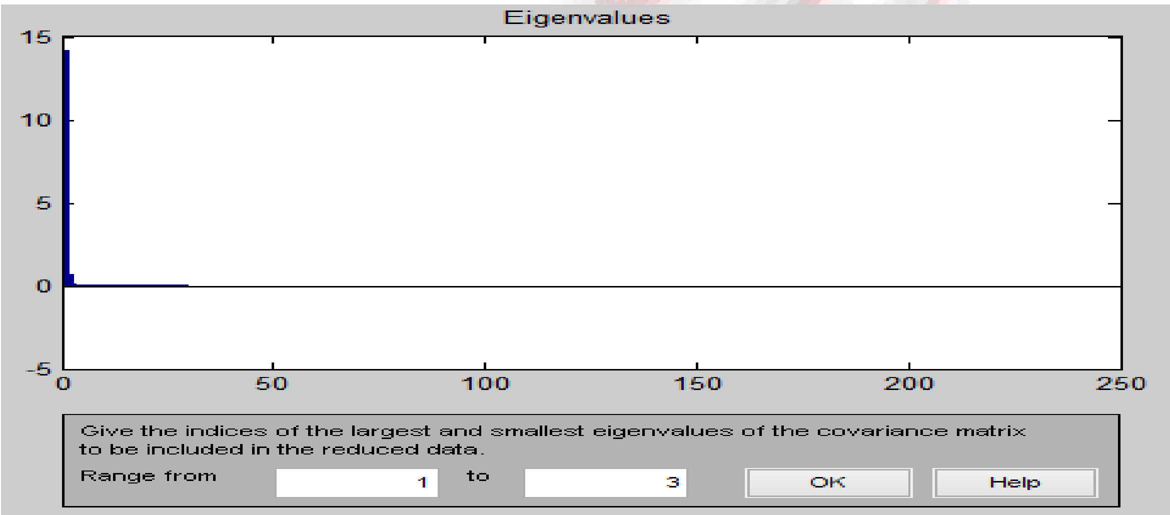


Figure 4 Dimension reduction matrix indices

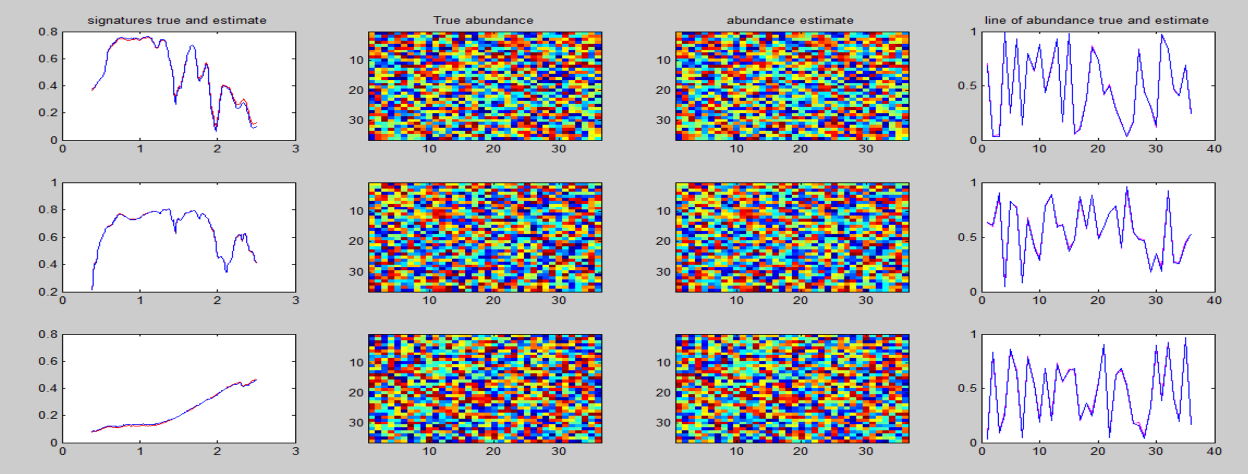


Figure 5 Signature true & estimate, Line of abundance true & estimate

Case 2: When two images are different

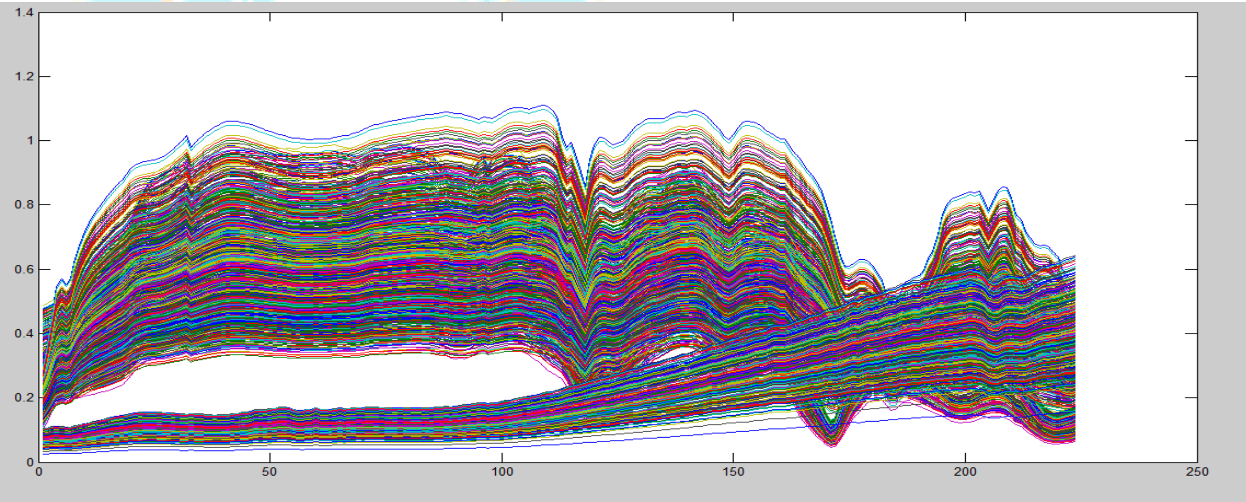


Figure 6 Pixel map of Input Image 1.

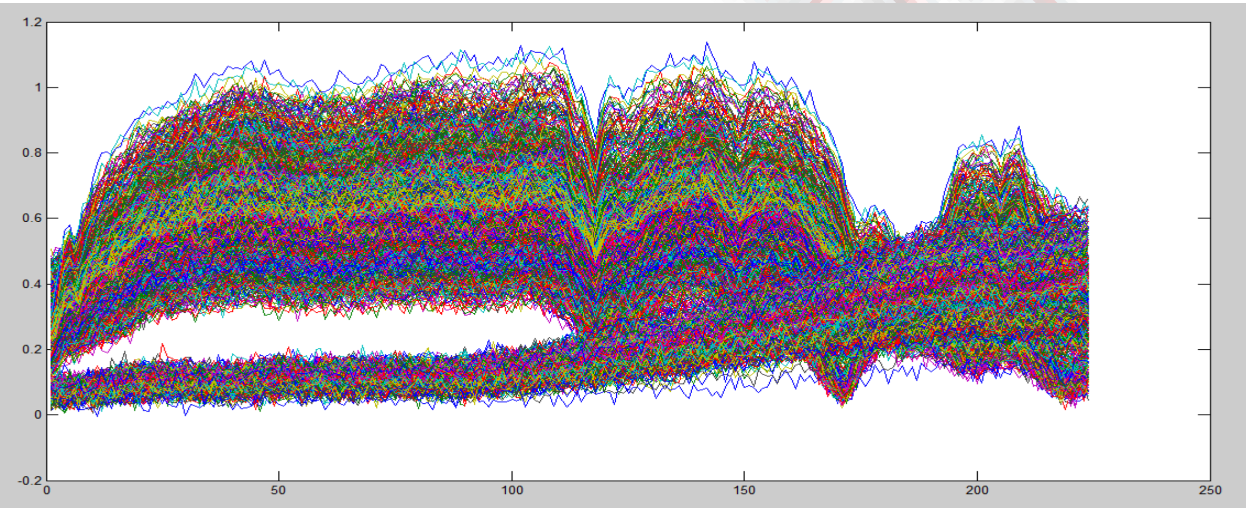


Figure 7 Pixel map of Input Image 2 with noise

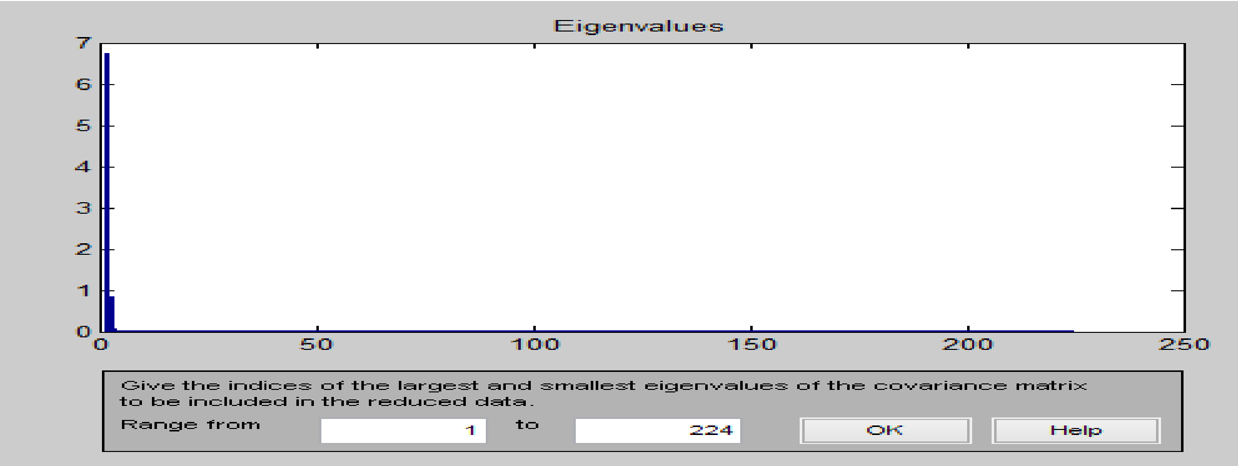


Figure 8 Dimension reduction matrix indices

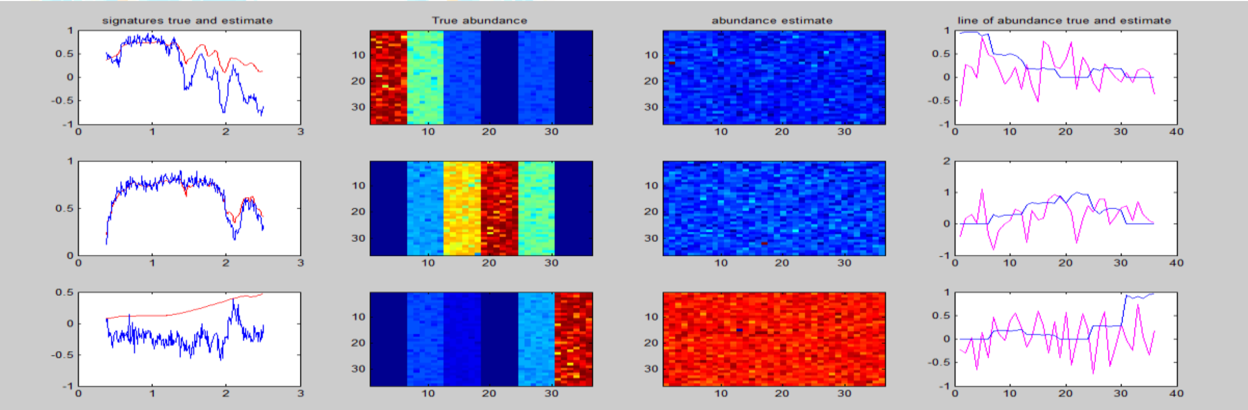


Figure 9 Signature true & estimate, Line of abundance true & estimate

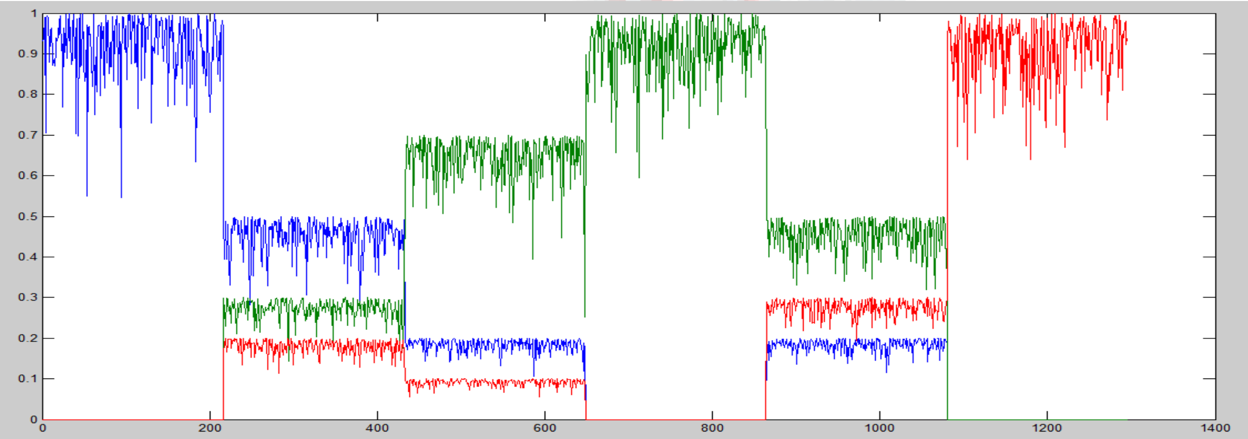


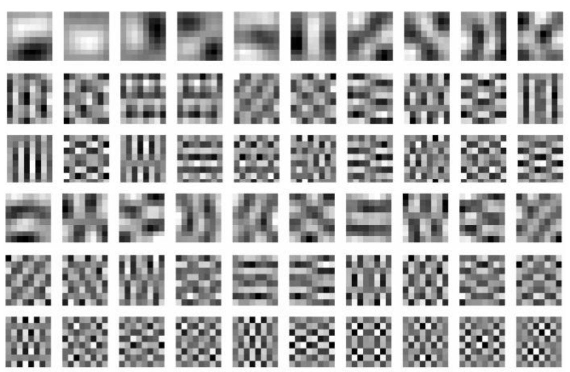
Figure 10 Change Map

```
Carnallite NMNH98011
Ammonioalunite NMNH145596
Biotite HS28.3B
***      SNR= 29.9919dB
***      Ilumination perturbation: on
***      Signature variability: on
```

IV. Summary of Results

PCA-based change detection can capture maximum variances in a finite number of orthogonal components based on eigenvector analysis of the data correlation matrix. For bi-temporal and multi-spectral images, a two-dimensional feature space can be produced for each spectral channel. In this feature space the position of each pixel is given by a point, relative to the random vector. No change pixels from both points in time are closely correlated and they cluster along the first principal component axis whereas the change pixels are positioned away from this axis in the feature space. Thus, we can obtain a quantification of the degree of change for a given pixel. Independent component analysis (ICA) as an extension to PCA has been proposed as a generic statistical model for images, which can be viewed as a generalization of PCA since it concerns not only with second-order dependencies but also higher-order dependencies between variables. ICA is an unsupervised source separation process for multi-channel signal processing to separate mixed signals. ICA aims at capturing statistical structure in images by exploiting higher-order statistical structure beyond second order information. The goal of ICA is to linearly transform the data such that the transformed variables are as statistically independent from each other as possible.

In this work, FastICA algorithm is used to implement the de-mixing model, which is include a PCA pre-processing step for whitening data. It can project an image sequence directly onto the axes formed by the n independent source images resulting from FastICA. The ICA-based change detection results map is shown in Fig.4.9. The experimental results in figures 11 & 12 show the effectiveness of proposed change detection approach.



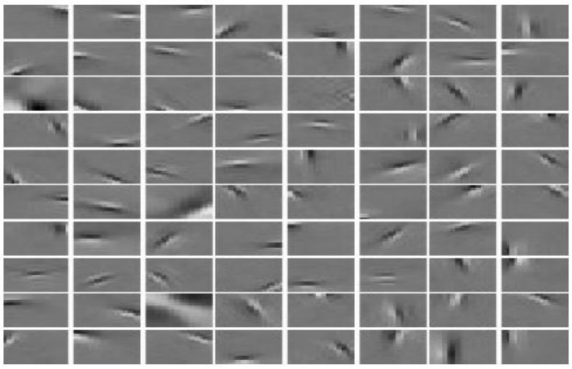


Figure 11 PCA based vectors extracted from image

Figure 12 ICA based vectors extracted from image

V. CONCLUSIONS

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 real and synthetic 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.

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