A Performance Analysis of Unsupervised Change Detection Method for Hyper spectral Images

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Abstract— The most significant recent breakthrough in remote sensing has been the development of hyper spectral sensors and software to analyze the resulting image data. Fifteen years ago only the spectral remote sensing experts had access to hyper spectral images or many software tools to take advantage of such images. Over the past decade hyper spectral image analysis has matured into one of the most powerful and fastest growing technologies in the field of remote sensing. 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 mainly spectrally over determined, which means that 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. In order to detect the changes that may occur due to various natural hazards like earthquake, floods or many more in several areas, there is an efficient way to identify these changes without visiting the sites by analyzing the changes through remote sensing satellites like Landsat, SPOT etc. which provides digital images of hyper spectral images and through change detection algorithms these changes may become easy to detect. To complete this goal, feature extraction is considered as an essential-weapon to analyze an image properly. In this paper, different digital lesion images have been analyzed based on unsupervised image acquisition, pre-processing, and dimension reduction techniques.. After this, a graphical user interface and independent component analysis has been designed for the probability detection and then a comprehensive discussion has been explored based on the obtained results.

Keywords— *Hyper spectral image analysis, Image Acquisition, Feature Extraction, Graphical User Interface, target detection, remote sensing, change detection algorithms.*

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I. INTRODUCTION

Hyperspectral images offer more detailed and important additional information on spectral changes so as to present efficient and promising change detection performance. The main challenge in this field is how to take advantage of the spectral information at such a high dimension. These Images have dozens to hundreds of narrow contiguous bands. Vast quantities of data because of the number of bands simultaneously imaged, creating a 3-dimensional high resolution image cube[1].Hyperspectral images are spectrally over determined, as they provide ample spectral information to identify and distinguish between spectrally similar (but unique) materials. Hyperspectral imagery provides the potential for more accurate, efficient and detailed information extraction than is possible with other types of remotely sensed data. Most multispectral imagers (e.g. Landsat, SPOT, AVHRR) measure the reflectance of Earth's surface material at a few wide wavelength bands which are being separated by spectral segments where no measurements are taken. Most of hyperspectral sensors measure reflected radiation as a series of narrow and contiguous wavelength bands. Hyperspectral imaging, also known as imaging spectrometry, is now a reasonably familiar and important concept in the world of remote sensing[13]. Change detection is the apprehension of change occurs in the world around us. The ability to detect change is much important in our everyday life. Only recently have various approaches begun to converge in terms of what it is and how it is carried out. As used here, the term change detection indicates primarily to the visual processes involved in first noticing a change. It denotes not only detection in proper manner (i.e., the observer reporting on the existence of the change), but also identification (reporting what the change is) and the localization (reporting where it is). Likewise, the focus is on behavioural measures and their interpretation rather than investigations into underlying neural systems[14]. Digital image classification uses the spectral information represented by the digital numbers in one or more spectral bands, and they attempts to classify each individual pixel based on this spectral information [12]. This type of classification is termed as spectral pattern recognition. In either case, the objective is to assign all pixels in the image to particular classes or themes (e.g. water, coniferous forest, deciduous forest, corn, wheat, etc.). The hyper spectral images are classified as supervised and unsupervised classification. Unsupervised classification in essence reverses the supervised classification process. The Spectral classes are firstly grouped, based solely on the numerical data information, and these are then matched by the viewer or analyst to information classes. Clustering algorithms are used to determine the statistical structures in the data. Usually, the analyst specifies how many groups or clusters are to be looked for in the data. In addition to specifying the desired number of classes, the analyst may also specify parameters related to the separation distance among the clusters and the variation within each cluster.

Thus, unsupervised classification is not completely without human intervention[14]. There are various techniques of detecting the changes in hyperspectral images such as Image differencing, Principal Component Analysis, Fast Independent Component Analysis etc.

II. PROPOSED WORK

At first an hyper spectral image is acquired with a remote sensing satellites. The proper interpretation of these images leads to increased change detection accuracy. The implementation of change detection of HSI system is illustrated in Fig. 1 below, and it consists of five general stages. After the image is acquired, the pre-processing step is done which at first determine the common difference between same scene of hyper spectral image but at two different times. After that in the feature selection method the header file is computed in matlab data file form in a workspace window of Matlab software. The image is analysed by adding noise to it and the change is detected by using dimension reduction method which uses two techniques. After it the change map is done by detecting the changes in graphical user interface and also by analysing the independent component analysis.

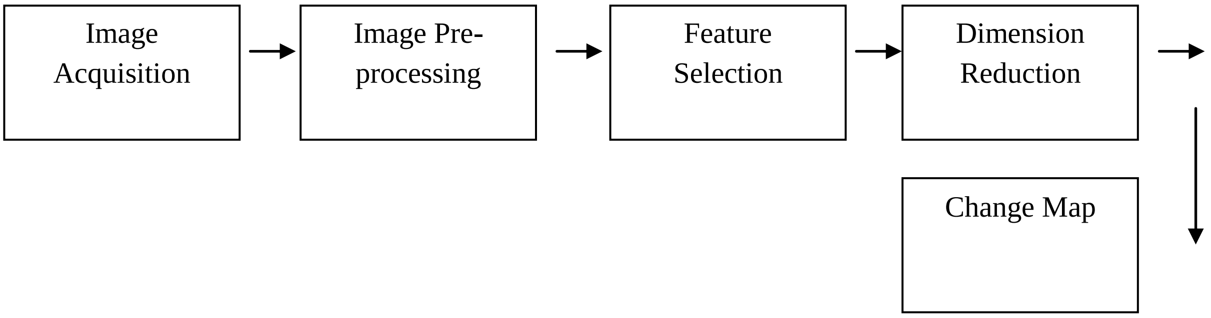

Figure 1: Implementation of change detection techniques for hyper spectral images

III. RESULT AND DISCUSSION

The HSI system performance detection is based on the Feature Extracted from the image analyzed. The experimental results are conducted using Matlab7.0. For this experiment image database is used from remotesensing.usgs.gov/gallery website.

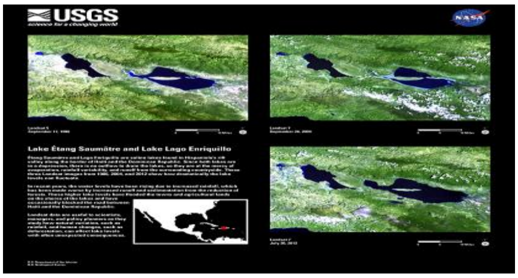

Figure 3.1: Input image

This is the input image of Lake Etang and Lake Lago taken for detection of change. These scenes are carried through remote sensing satellite like Landsat SPOT etc. The original image after taking is being extracted in the form of bands having same scene at different dates and years as shown in input image above. The images are shown below:

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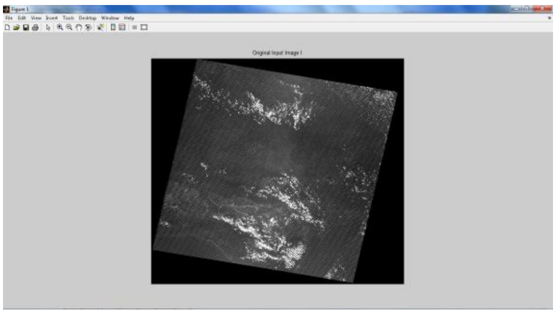

Figure 3.2: Band 1 image (26th Sept.,2004)

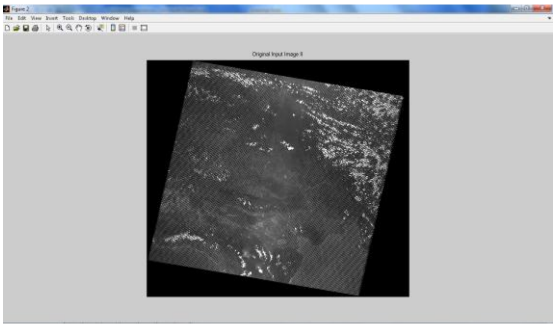

Figure 3.3: Band 1 image (30th July, 2012)

At first, in this step the most common and important technique i.e. Absolute Image Differencing is done for the above scenes at two different dates. Absolute Image differencing is a method of finding the changes between images. The difference between two images is calculated by finding the difference between each pixel in each image.

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The word "Pixel" represents as 'pix' means pictures and 'el' means elements. Therefore the pixels of an image represent the elements of that image. The pixel is a physical point or smallest addressable element of an image. In the hyperspectral imagery the change is determined by analyzing the two images of same parameters and of having same coverage area but captured at two different times.

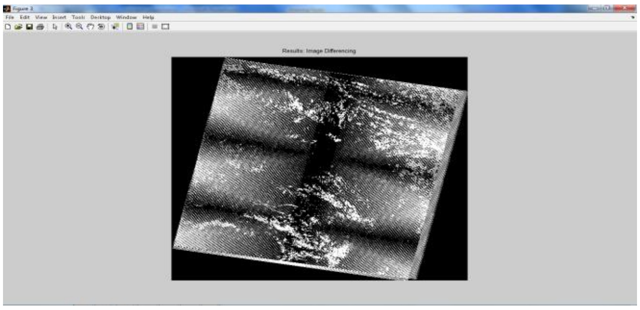

Figure 3.4: Result Of Absolute Image Differencing

After this technique, for the implementation of HSI there is a requirement of header file with defined parameters like size, bands, no. of lines and columns etc. Therefore to fulfill this requirement the matlab data file of above hyper spectral image is generated so that it may provide the information of image parameters. The matlab data file is then stored in workspace window of Matlab software. This is a matlab data file with reflectance sub image from data set.

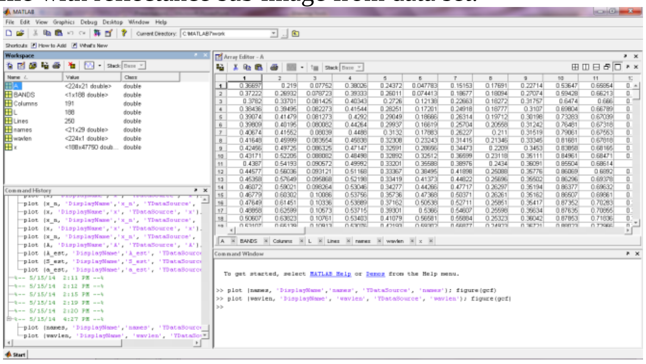

Figure 3.5: Matlab data file stored in Workspace Window

The feature selection part also extracts the sub image with spectral signatures and no. of wavelengths which define the range of these spectral signatures as shown below:

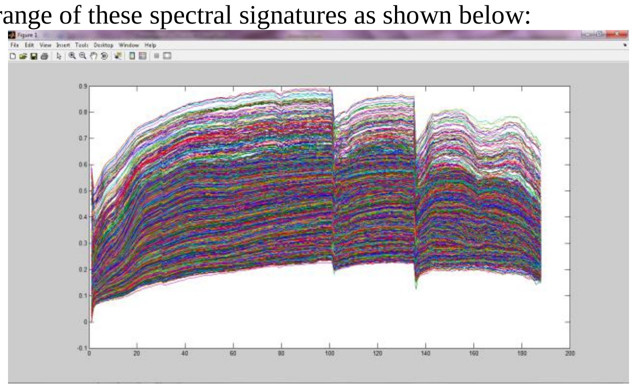

Figure 3.6: Subimage (channels× no. of pixels)

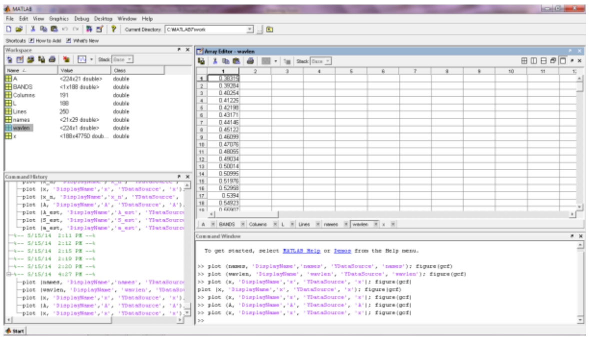

Figure 3.7: Number Of Wavelengths

For the implementation process it becomes a difficult task to detect the changes occurred in many of spectral segments simultaneously as shown in sub image fig.3.6. Therefore these spectral segments are subdivided into groups and assign them as a unique class of spectral signatures as shown in figure :

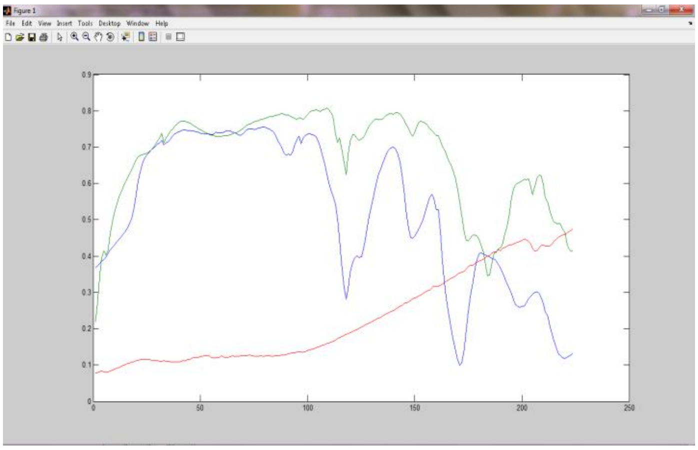

Figure 3.8: Extracted Spectral signatures from sub image

The next step is to add noise to the given image as shown above in figure 3.8.
The type of noise is atmospheric noise which may arise due to the reflections from electromagnetic spectrum.

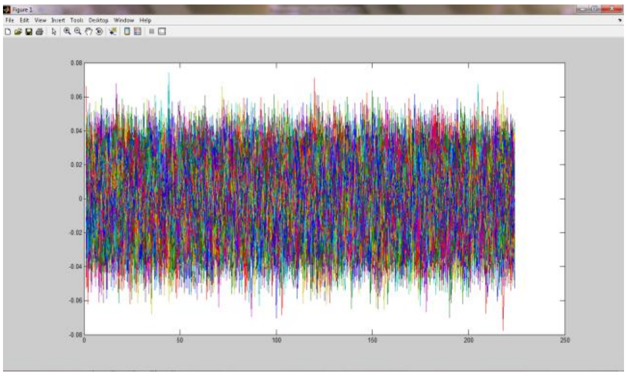

Figure 3.9: Atmospheric Noise

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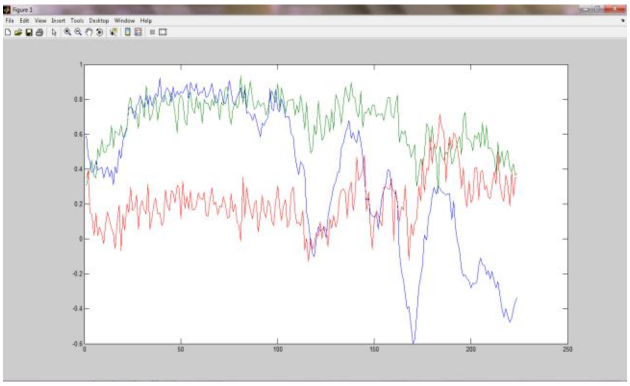

Figure 3.10: Effect of noise in input extracted spectral signatures

After adding noise , next step is the unmixing process in which the specific area of the image over which the change has been occurred can be determined to form a true abundance. The unmixing process depends on following cases ;

Case1: When there is no noise is added in the image, in that case SNR would remain zero and value of correlation co-efficient would also remain zero. The estimated endmembers selected for this process at different time and frequency are :

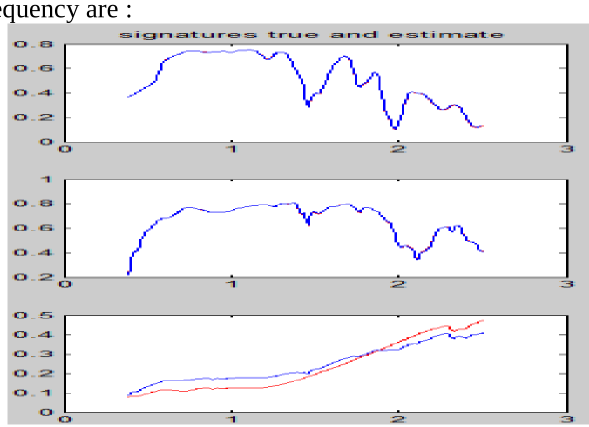

Figure 3.11: Endmembers generated for true and estimated abundance

As there is no noise added in the image, then there will be no change in the pixels of true abundance and estimated abundance as shown below :

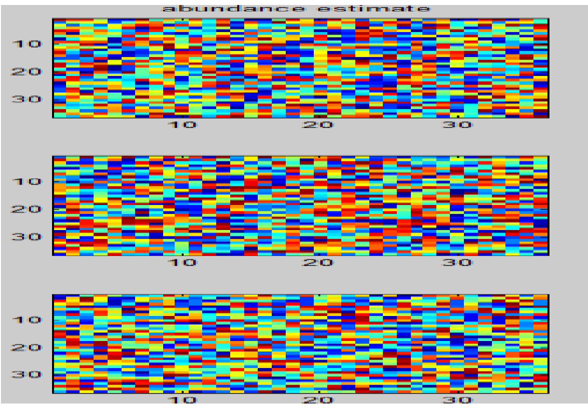

Figure 3.12: Estimated abundance when no noise is added

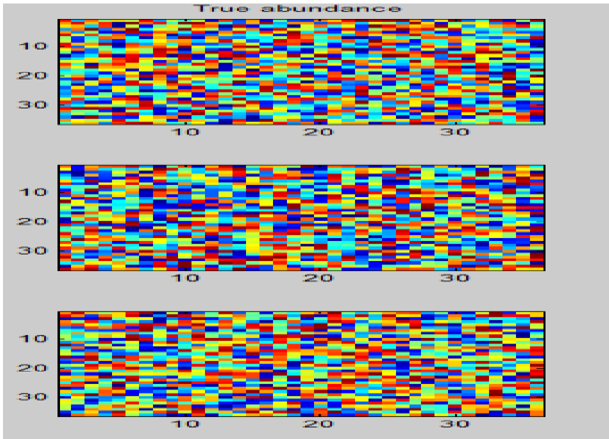

Figure 3.13: True abundance

As there is no noise added in the image it means there will be no change in true and estimated abundance. But after analyzing the image or the area there may be some noise present due to some previous factors or hazards. Therefore for the accuracy of results to detect the independent spectral components the Fast Independent Component Analysis method is used so that the unique and independent spectral components which are termed as line of true abundance instead of noisy components can be detected.

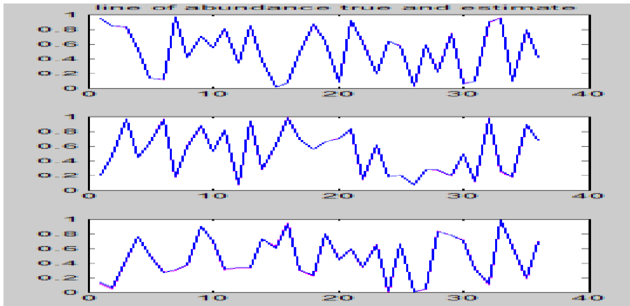

Figure 3.14: Figure 4.14: Output obtained from FICA

When noise is added in a image, in that case there is a requirement of finding the change using change detection algorithms. At first, the noisy sub image is shown below :

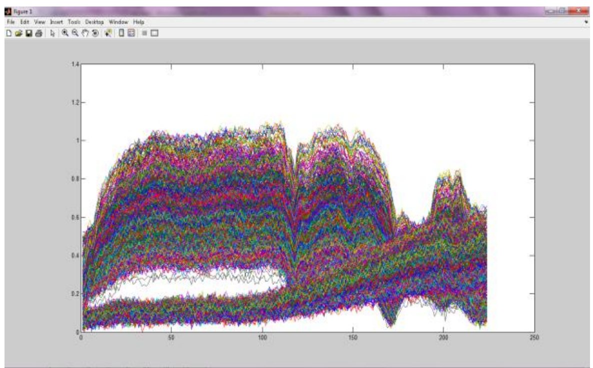
Figure 3.15: Noisy sub image

The selected endmembers with noise from the sub image is shown below :

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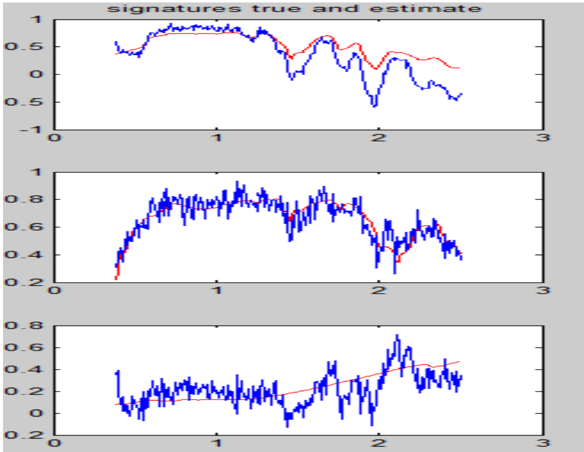

Figure 3.16: Selected end members with noisy estimated image

Since it is difficult to detect the particular area or a point over which the change has occurred from whole scene. To achieve this, the dimension reduction method is used. Principal Component Analysis (PCA) is one of the best method of dimension reduction which is used to reduce the image into bands so that it become easy to detect the change in which particular band if present. In case of PCA the Eigen values are specified using Co-variance matrix. The result of true abundance after applying the PCA to estimated abundance is shown below :

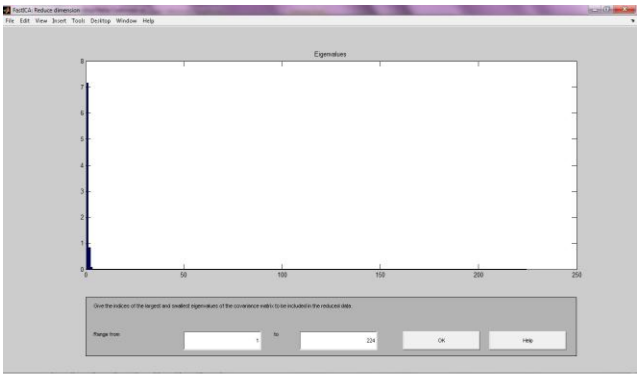

Figure 3.17: Range of Eigen values using dimension reduction

The dimension reduction provides the information of particular area (true abundance) by dividing the image i.e. estimated abundance into sub-bands as shown in figure :

:

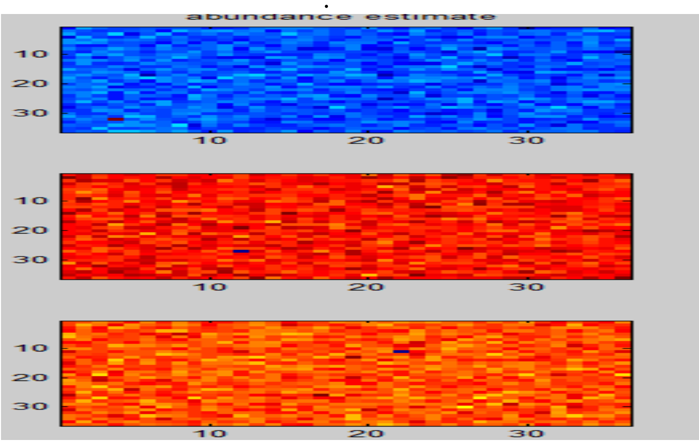

Figure 3.18: Estimated Abundance

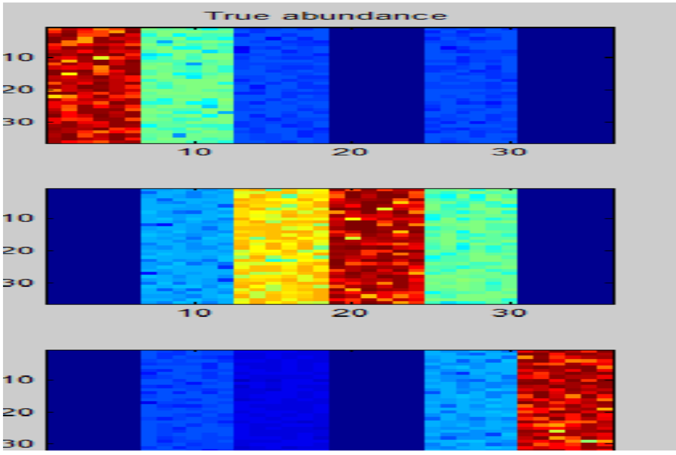

Figure 3.19: True Abundance after using PCA

After applying the PCA the whole image is subdivided into sub-bands for dimension reduction of image pixels. But if there is a requirement of detection of independent components then the Fast Independent Component Analysis method is used. The significance of using FICA is that it can detect only the particular area where spikes of estimated abundance are high and in that area alarm signal can be generated before happening the disasters.

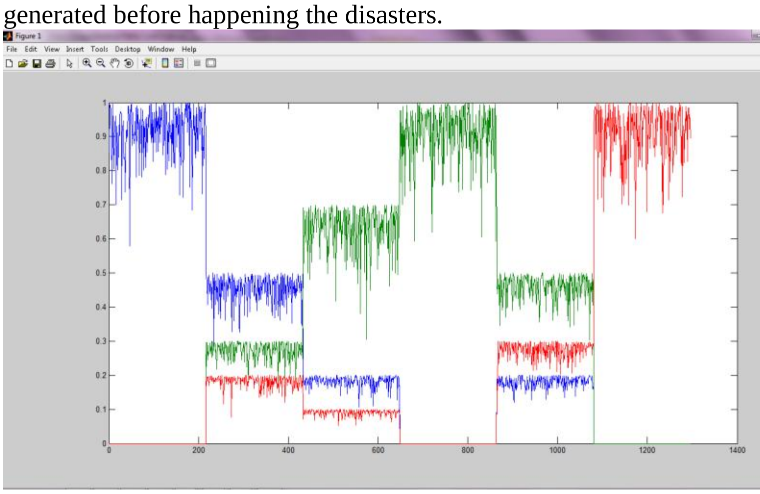

Figure 3.20: Result Of PCA and FIC

CONCLUSION

The different methods have been discussed to find the change detection in various hyper spectral images. The different methods implemented are image acquisition, pre-processing, feature selection and dimension reduction methods. Two techniques are used for enhancement of this process, PCA and FICA. After determining the endmembers for spectral signatures the dimensions are reduced in order to measure the small amount of change in even a very little area if present. This can be accomplished by using technique PCA which is a linear transformation in which new variables are the linear function of old variables by creating a new co-ordinates system for data sets such that the greatest variance producing in the data sets comes to lie on first axis, the second greatest variance on the second axis and so forth. After applying the dimension reduction method if there is a requirement of determining independent components even in that particular dimension reduced area the FICA technique is used. By applying this algorithm the effect of disasters or any natural hazards can be detected in the independent components so that the alarm signal can be generated before happening the disasters.

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