Plants Change Detection in Forest Areas based on Satellite Imagery using Kernel MNF

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ABSTRACT
In this paper, proposes an efficient method for change detection in forest areas using panchromatic stereo imagery and Multispectral imagery using kernel minimum noise fraction analysis. Due to low spectral information it is difficult to extract the change features, since changes mostly occur together with other unrelated changes such as environmental changes and seasonal changes. Hence the kernel minimum noise factor approach is used to transform the image of simple dimension to high dimensional feature space using centering followed by computation of Eigen values and Eigen vectors of the given image. Image subtraction extracts the surface variation information from the two different input images. Images are classified and the change mask is generated using Iterated Canonical Discriminant Analysis (ICDA) with smaller number of pixel values. Two different examples are used for change detection analysis. Same amount of training samples are used here, by using this method more accurate change detection mask is achieved. In this paper, change detection is analyzed using different types of images from satellites resulting in accurate change detection mask. This is found to be better when compared with algorithms based on Random forest, k-means and one class support vector machine.

General Terms
Change detection Algorithm and Change mask Generation using ICDA.

Keywords
Change detection, kernel minimum noise factor (kMNF), image subtraction, centering, Iterated canonical Discriminant Analysis (ICDA), panchromatic image, multispectral image.

1. INTRODUCTION
A comprehensive understanding of global change is very important for the development of human society. Change detection is the process of identifying the state of object by observing at it different times. The remotely sensed data obtained from earth orbiting satellite is mainly used for change detection because of its repetitive coverage and short intervals. Change detection is widely used in diverse applications as vegetation monitoring, land use change analysis and also used in assessment of deforestation, Disaster monitoring in snow melt conditions, Daylight analysis of thermal characteristics and other environmental changes. The change detection in land cover results in radiance values, land cover changes varies with respect to the radiance values. Forest management and observation are fundamental and difficult tasks. The automatic monitoring of changes in forest region has drawn the interest particularly after the storm and other natural disaster. Satellite data are a valuable data source from which change information can be efficiently extracted for larger region. The most important change detection is the Vegetation Detection and it can be well identified through band by band calculation. Changes are detected in the regions of same area at different periods is of great interest. This process has many applications in different fields. Change detection methods mostly based on threshold methods and boundary values. Some of the methods discussed in the previous work are Thresholding technique, Digital change detection technique, Image regression.

2. LITERATURE SURVEY
The change detection methods in the beginning period are discussed in [1]-[4]. In this paper, different types of images were discussed based on the change detection analysis. The images used are the Panchromatic is called as a black and white image or Grey scale image it has low spectral values but high spatial resolution. The use of multispectral data is very essential in remote sensing areas related to terrain change detection. In order to use the complete change features from all the channels, the change vector analyses (CVAs) in earlier methods [5]-[7] were proposed to analyze more change features, which records only the total intensity of radiation falling on each pixel of an image. Hyperspectral image is used to obtain the spectrum or wavelength for each pixel of a scene, with the purpose of identifying the objects and the materials also used for detecting process. In hyperspectral image divides the spectrum into many more bands and this technique of dividing images into bands can be extended beyond the visible range. Multivariate alteration detection (MAD) [8] and the Principal component analysis (PCA) is used in [9] were used to highlight changes by transforming multi- or hyperspectral data in other feature space. The unsupervised method of change detection using k means clustering is discussed in [10]. Recently, more techniques are reported such as IR-MAD [11]. The Unsupervised kernel methods are discussed in [12]-[15]. Kernel-based change detection methods and Bayesian criterion is given in [16] to improve change detection accuracy and efficiency. Kernel analysis is also called as a pattern analysis algorithm. Thestatistical stability, robustness and computational efficiency are the three properties were identified using pattern analysis algorithm.

Change detection can be expressed as a particular case of the multitemporal image classification problem. There are two main approaches were explained in the literature namely (1) post classification comparison and (2) pre-classification enhancement in the earlier case, the two images used for change detection analysis are independently classified and co-registered, and an algorithm is used to predict the label changes between the two different dates. In the later case, the two datasets are combined and single classification is performed [17]-[19]. The post classification approach fails

because it depends on the accuracy of two independent classifiers. Region based change detection is discussed in [20]. Traditional change detection techniques are based on the images of multiple dates using principal component analysis, change vector analysis or cross correlation analysis and image subtraction. If the changes are detected in space using spectral signature one can analyze the change features with the image. Change detection can be processed with both the supervised and unsupervised method. Supervised method requires a labelled image. In case of Non linearity, unsupervised method performs better than the supervised method. Trained data or Example data is not required for unsupervised method. It does not require a labelled image at time period 1 to learn from than to generalize to the resultant image at time period 2. Threshold based image differencing techniques were used suitable threshold are chosen under the Bayesian criteria. The kernel method is an unsupervised change detection method used for centering, clustering and classification followed by an ICDA method for generating the change detection mask.

3. PROPOSED ALGORITHM

In the Proposed method two images are considered as an input. The images were taken from OrbView3, the two images at different time period is subtracted using image subtraction and subtracted data results the pixel intensity variation. From the image subtraction kMNF analysis is done followed by ICDA method for change map generation.

3.1 Images Used

In this paper, Change detection is analyzed with two different types of Data sets, the panchromatic images are obtained from satellite Orbview3, launched on an OSC launch vehicle from (Pegasus-XL) from VAFB, CA, USA. It can acquire both the panchromatic stereo images of 2.5m and multispectral images. If only panchromatic images are available, the Principal component analysis, Multivariate alteration Detection and IR-MAD which makes the change detection is a challenging hypothesis. The images are taken from van vihar, Bhopal, Madhya Pradesh. The latitude and longitude information is given as 23.2414N; 77.3741E. Karawai, East Aru Tengah, Kepulauan Aru Regency, Maluku, Indonesia the latitude and longitude is -5.503255N; 134.721933E.

Change detection using Multispectral imagery is also discussed. Images are taken from OrbView3 space imaging satellite. The Panchromatic and Multispectral images are analyzed using kernel minimum noise fraction. And the change detection map is generated using ICDA.

3.2 Image Subtraction

Image subtraction is called as a pixel subtraction it is a process whereby the digital numeric value of one pixel or whole image is subtracted from another image. This is primarily done for detection changes between two images. Image subtraction has the most extensive application in a wide variety of images and geographical environments. Image subtraction is mostly conducted on the basis of gray values. There are many types of change detection methods for spectral change detection methods. They can be classified as three categories they are characteristic analysis of spectral type, time series analysis and vector analysis of spectral changes. The Changed region and the unchanged region are determined by selecting the appropriate threshold values of Gray levels in the subtraction image. The obtained gray values of the subtracted image shows the differences of Corresponding pixels of two given input images. One of the advantages is, in the subtraction image the threshold value selecting operation is performed only once. To best separate the areas of real change and the rest of the change areas due to random factors a suitable threshold value is selected. Gaussian distribution is mostly approximated in the gray values of the subtracted images, the unchanged pixels are grouped into an average value and the changed pixels are in the two tails of the distribution. It is beneficial for collecting change information at areas such as the beach zones, estuaries and Water channels. It is widely used in detecting coastal environmental changes, temperate forests changes, tropical forests Changes, and crop analysis. Image change detection, image regression and PCA are used in the earlier change detection process.

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3.3 kMNF Analysis

Kernel methods provides a common framework for machine learning problems such as classifications, regression, clustering, visualization and density estimation with heterogeneous types of data, contains time series images, strings or objects. Kernel method is a pattern analysis algorithm and its solution comprises two parts: a module that performs the mapping into the embedding or feature space and a learning algorithm designed to discover non-linear patterns in that space. For detecting non linear relations has been the focus of much research in statistics and machine learning and the resulting algorithms are easy to understood and efficient. we will see that there is a computational shortcut which makes it possible to represent non-linear patterns efficiently in high-dimensional spaces to ensure adequate representational power are the two main reasons to make use if the kernel work. These kernel versions are based upon a dual formulation also termed as a Q-mode analysis in which the data enter into the analysis through the inner products in the Gram matrix only. Here, we are considering multivariate measurements represented by the m by n data matrix A (given as one row per observation, one column per spectral band) as being the sum of an uncorrelated signal AS and noise An.

$$A = As + An \qquad (1)$$

A is the variance–covariance of the matrix CA is equal to the sum of the variance–covariance matrices of the signal CS and the noise Cn.

$$CA = Cs + Cn \qquad (2)$$

We then project the originally measured variables A onto the direction vector a in the feature space, which minimize the noise fraction denoted as N or maximizing the 1/N. Noise fraction is defined as the ratio between variance of the

$$N = \frac{e' C_n e}{e' C_s e} = \frac{e' A'_n A_n e}{e' A' Ae} \qquad (3)$$

Where A and An are given as column centered matrix. The regularized version of 1/N is

$$\frac{1}{N} = \frac{e' A' Ae}{e' \left[(1-\lambda) A'_n A_n + \lambda I\right] e} \qquad (4)$$

Where I is denoted as Identity matrix. To satisfy the non-linearity in the data, a kernel version of the regularized MNF transformation can be obtained by re-parameterization, Considering $e \propto A' d$.

$$\frac{1}{N} = \frac{d'AA'\,AA'\,d}{d[(1-\lambda)AA'_n(AA'_n) + \lambda AA']d} \quad (5)$$

The matrices AA'are the Gram matrix and AA' n contain the combinations of inner products of the rows of A. Replace these inner products by inner products of non- linear mappings of the originally measured variables into a feature of higher dimension and performs the kernel substitution also called kernel trick. By replacing the inner products by kernel function we obtain,

$$\frac{1}{N} = \frac{d'K^2 d}{d'[(1-\lambda)\,K_n\,K'_n + \lambda K]d} \quad (6)$$

In equation (4), KN is a kernelized version of the residual form of a quadratic surface in a 3x3 matrix.

$$K_n = K - \frac{K_1 + 2K_2 + K_3 + 2K_4 + 5K_5 + 2K_6 + K_7 + 2K_8 + K_9}{9} \quad (7)$$

Where is the usual kernel matrix between the data points, and K1,...., K9 are the kernel matrix between the data points in the center position in the matrix given below.

$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

Once the correct parameters are selected, Partitioning algorithm returns the representatives of the clusters, corresponding to each centroids value. Finally, these training samples are used in a kernel minimum-distance classification that generates the change map. Here, K5 is equal to K and re-parameterization is done to find the direction using Rayleigh scattering. In the change detection method each observed training data is kernelized before the multiplication.

$$k\,i = kbi \quad (8)$$

To calculate one of the change image based on several kMNF variates, we norm these variates to unit variance, square them, and summing up all the variance values are given as

$$\chi^2 = \sum_{i=1}^{m} \frac{k_i^2}{\sigma^2} \quad (9)$$

Pixels characterized by high values are change pixels. The pixels close to zero are no change pixels. We use the Gaussian kernel function hence, we choose the width of the kernel as σ and the regularization parameter is given as λ. Generally the values of (σ, λ) is given as $\lambda = 0$ and the regularization parameter is equal to the mean value of all pair wise distances between the observations in the original feature space. The set (σ, λ) is found by using grid search. Particularly, these methods are developed under a method called kernel method [16]. Kernel minimum noise fraction gives better suppression for both the noise and the signal in the change background. These kernel versions of PCA, MAF and MNF handle the non linearity in the test data.

3.4 Change Mask Generation

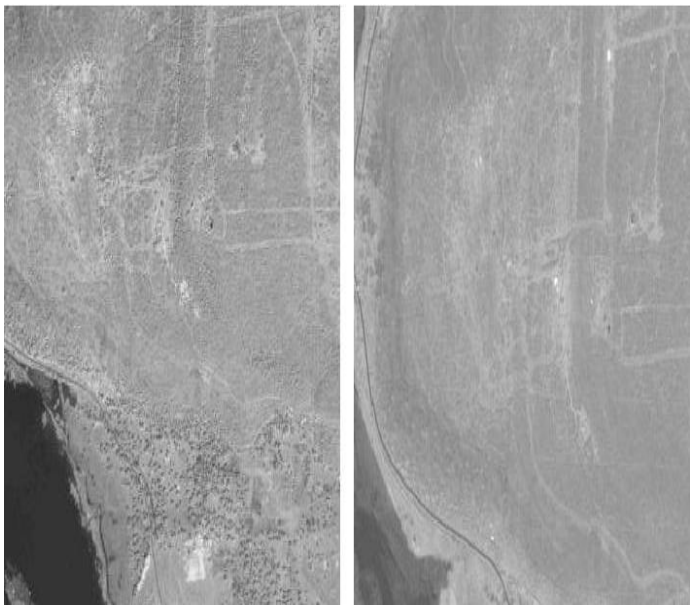
The proposed ICDA (Iterated Canonical Discriminant analysis) is a supervised method. As the change pixels are lesser than the no-forest-change pixels, the comparison between the two images were made in terms of Kappa accuracy as the overall accuracy is not very sensitive in this case. The main principle in the traditional CDA (canonical Discriminant analysis) is to find projections in multi or Hypervariate feature space which gives maximum separation between the groups (or also called classes or populations) of the data, Here, we first use CDA with two groups based on a selecting the region of interest, rest of the image is the other group training area which then constitutes one of the two groups. Less number of pixels is enough to generate the change detection mask but it raises some potential problem: the rest of the image may contain regions that actually belong to the first group. To determine such regions and to update the training area using a series of iterations, new training areas for the CDA are selected by automatically thresholding the canonical variate calculated in the previous iteration. Region of interest can also be selected for the change detection. Iterations stops when the canonical correlation stops improving. Here, consider k groups with n1…nk multivariate (p-dimensional) observations {Bij}, where i is denoted as the group index and the j is denoted as the (multivariate) observation number. The group means are denoted as B1....Bk and the overall mean is denoted as B.

$$B = \frac{1}{n_i} \sum_{j=1}^{n_i} Bij \quad (10)$$

4. RESULTS AND DISCUSSIONS

4.1 Panchromatic imagery

From the two given input images, change points are extracted using kernel minimum noise fraction. Where each pixels are kernelized using kernel or kernel trick. The generated training vectors are considered as a single training vector and given as an input to the Iterated Canonical Discriminant analysis. One class support vector machine, k-means classifier and Random-Forests are the Classifiers used in the earlier days have many false alarms. ICDA has reduced the false alarms compared to the above mentioned classifiers.



Input image 1 Input image 2

Fig 1: Two input Data set from Van vihar National park, Madhya Pradesh, Bhopal (2005, 2008)

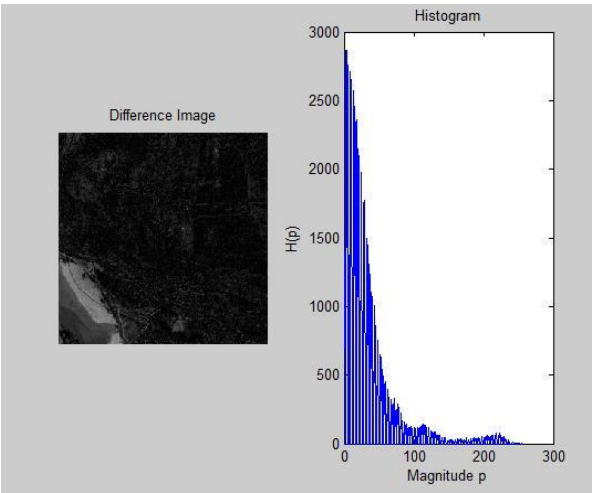


Fig 2: Histogram variation of a difference image intensity of pixel versus magnitude of pixel

The above figure shows the histogram variation of an input image of intensity of pixel with respect to the Magnitude of pixels.

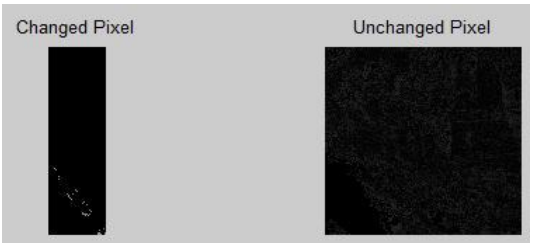


Fig 3: Extracted changed and unchanged pixels from the input images.

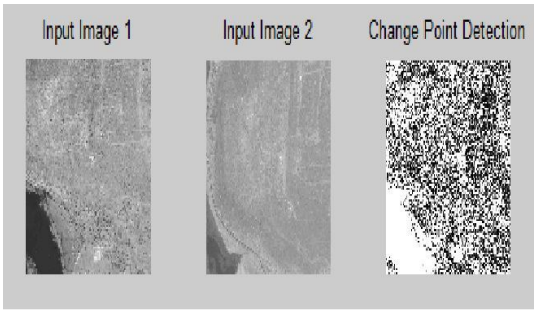


Fig 4: Extracted change points of two input images

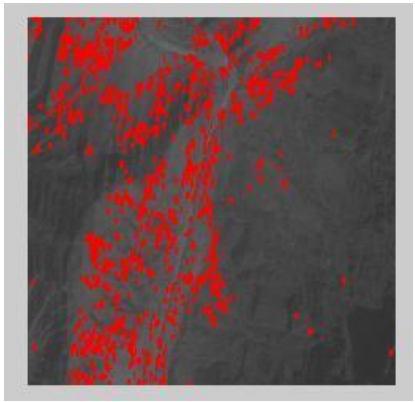


Fig 5: Generated Change mask result for the panchromatic images

Change mask describes the location where change has been made in the image. ICDA requires a few numbers of pixels to generate the change mask to identify the change areas.

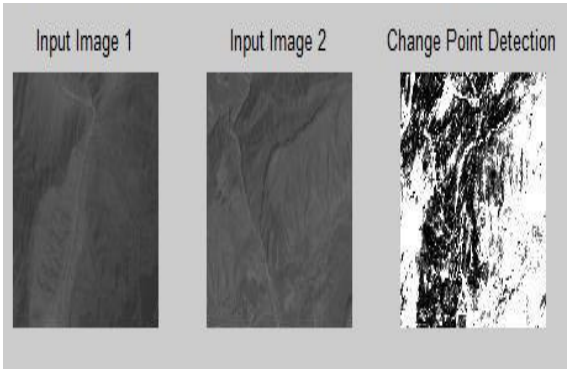


Fig 6: Data from Gulf of Aden (2006-2008)

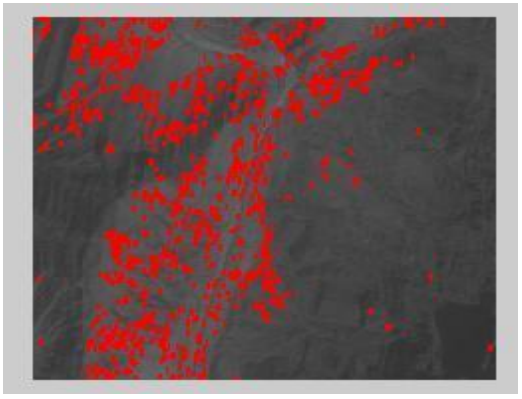


Fig 7: Digitized change reference data.

Some examples are given in fig.6 for the panchromatic images and their change detection is extracted in Fig.7.

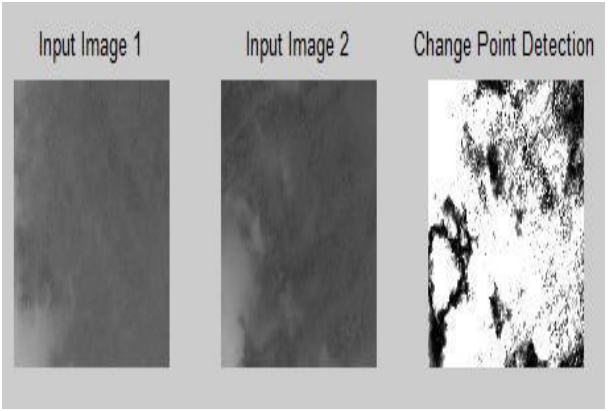


Fig 8: Data set from North 6, Yemen (2006-2008)

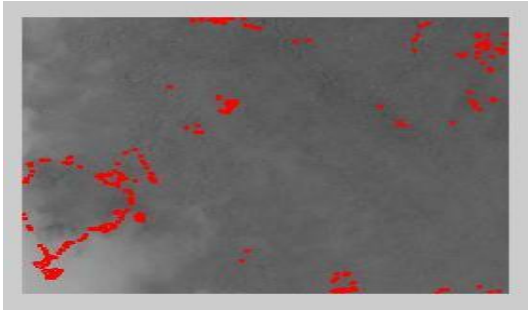
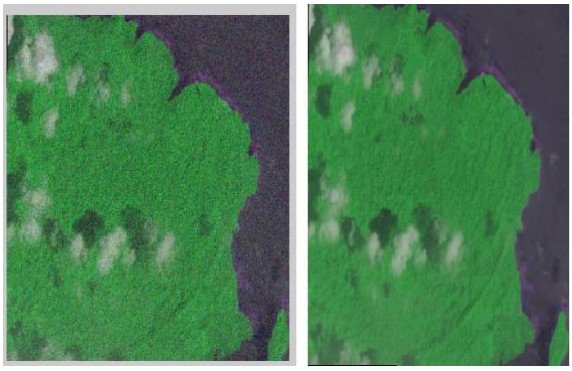


Fig 9: Change mask image of Data from Fig 8

4.2 Multispectral Imagery



Input image 1 Input image 2

Fig. 10.Karawai, East Aru Tengah, Kepulauan Aru Regency, Maluku, Indonesia (2004 and 2006)

In this paper, it is given that change detection can also obtained from multispectral image. It is optically acquired in more than one spectral values or wavelength interval. Each individual image is of same physical area and scale but of a different spectral band. The two given input images are subtracted to obtain the basic difference between the two images, which is given as Subtraction of two images followed by Kernel minimum noise fraction is achieved; and it is a non-linear machine learning algorithm mainly used for pattern analysis and clustering and so on. It consists of the data to form a single cluster in the infinite feature space induced by the Gaussian kernel and determined the support vectors delimiting it. In the input space the support vectors are analyzed. The inner products of the original data are replaced by the inner products between non linear mappings into higher dimensional feature space hence it is called as kernel method. The kernel substitution is also called as a kernel trick and these inner products between the mappings are replaced by kernel function; all the quantities in the mapping are replaced by a kernel function. From which it is clear that we do not know the non-linearity explicitly. kMNF analysis handles the non- linearity by implicitly transforming the data into higher dimensional feature space. Using the kMNF analysis clustering, centering and classification is performed the resultant.

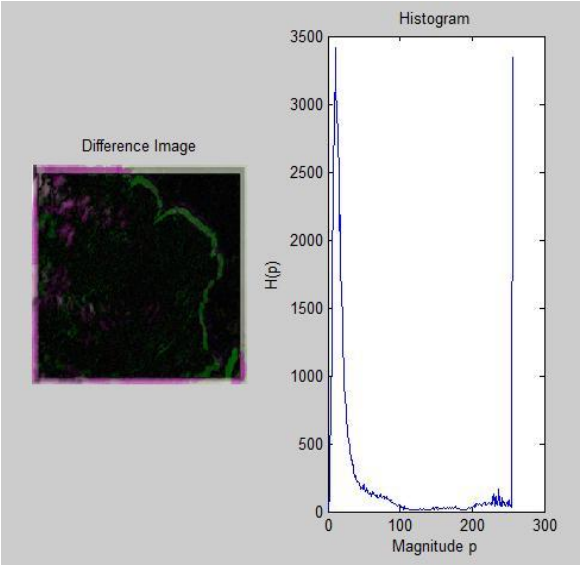


Fig 11: Histogram of pixel variation of a difference image

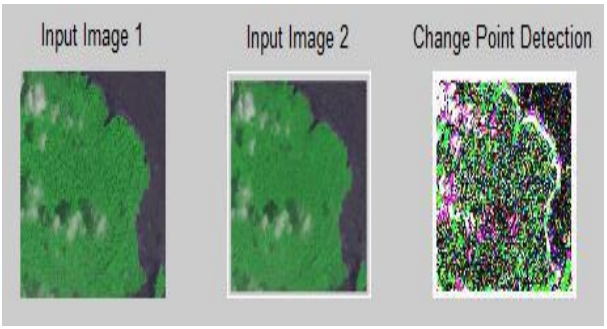


Fig 12: Change areas from two given multispectral images

The above figure illustrates the pixel change detection from the two input images. Training vectors are used to determine the changes in the desired direction.

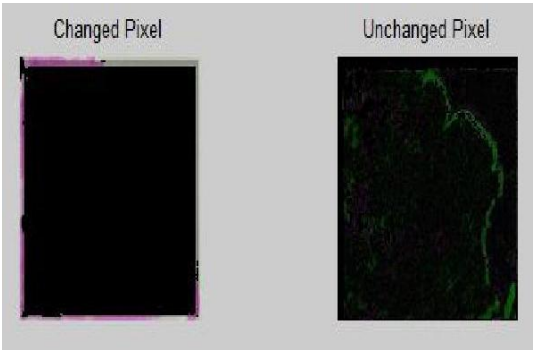


Fig 13: Changed and Unchanged pixels from the two input images

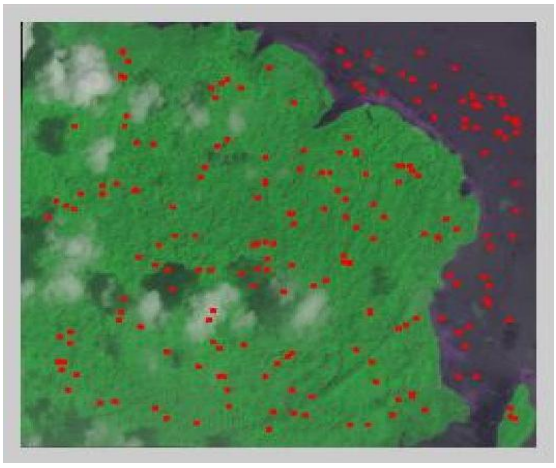


Fig 14: Generated Change mask for the fig.10

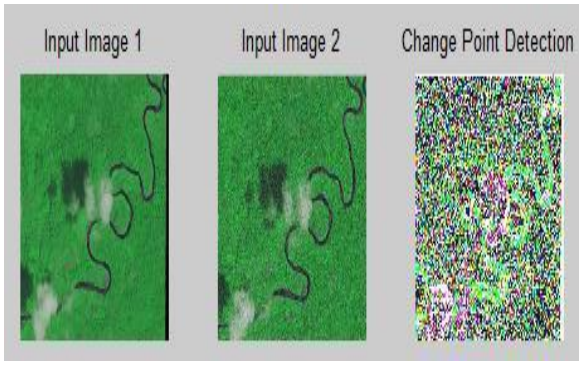


Fig 15: Autonomous Region of Bougainville, Papua, New Guinea

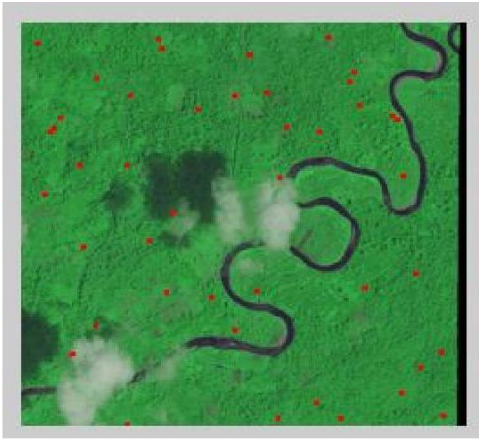
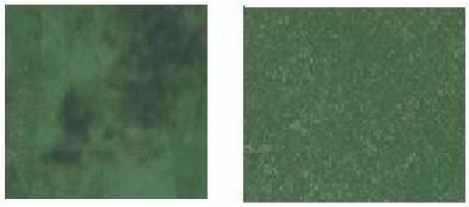
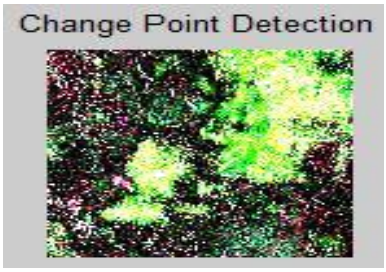


Fig 16: Digitized change reference data of Fig.15



Input image 1 Input image 2



Extracted change point detection

Fig 17: Extracted Change point Detection of Cascades Road, North Cascade WA, Australia

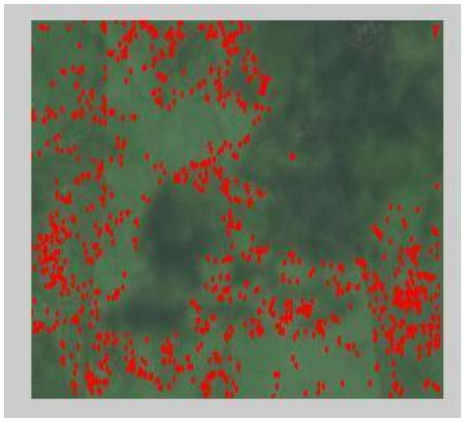


Fig 18: .Digitized change reference data of Fig.17

Change detection is an essential task in natural resource development and management. The proposed work is done for change detection in Multispectral images and panchromatic images using kMNF analysis. The resultant output shows accurate changes between the given inputs. The change detection method purely based on a intensity and segmentation method which will extract the changes from the given image. The images used are [1200x1200] for panchromatic images and [1153x1153] for multispectral images. The data obtained are the uncompressed data. As the approach followed is intensity based one. Threshold values plays an important role for intensity variation by setting threshold values change features are estimated. In kMNF analysis which checks the neighborhood pixels in array of elements in matrix to convert it to a kernel matrix. The kernel output is a training vector in a specified direction is given as an input to the ICDA method which generate the change mask locating the points where changes has been actually occurred in the resultant image. The change detection mask of the multispectral images shows better results when compared to the panchromatic image change detection.

5. CONCLUSION

In this paper, change detection is done for forest regions using different satellite images such as panchromatic and multispectral images. Images from two different periods are collected and analysed for both the panchromatic and multispectral images, and the two images are subtracted to collect the attributes of the change points. Kernel minimum noise fraction analysis is used to determine the change features in all direction by using re-parameterisation technique. Change mask is presented using ICDA Algorithm with reference to the input image. From the obtained results, it is clear that the change detection in multispectral image is more accurate than the panchromatic image. The 2D change features are processed in a high dimensional feature space using kMNF analysis to highlight the change features. The kMNF value or region of interest is given as an input to the ICDA method to generate the change mask pointing the change areas in the resultant image. The main advantage of this method is that requires only a smaller number of pixels to generate the change features. As change detection is more useful in many areas as this method can also be implemented for change detection of urban areas and snow/ice change detection on earth surface using Earth resource satellite images.

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