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Analysis of Various Change Detection Techniques Using Satellite Images

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Abstract— **Change detection implies quantifying temporal effects using multi temporal dataset. The Remote sensing data has become a heart of change detection technique because of its high temporal frequency, digital computation, synoptic view and wider selection of spatial and spectral resolution. The general objectives of change detection in remote sensing include recognizing the geographical location and type of changes, quantifying the changes, and assessing the accuracy of change detection results. In this paper analyses the various change detection techniques using satellite images. Three remote sensing techniques, including Image Differencing, Principal Component Analysis and Change Vector Analysis used to detect the changes. To carry out these techniques, Landsat8 satellite images were used to recognize changes in study area. The efficiency of these method in study area were compared using post classification method and carry out accuracy assessment. The results shows that change vector analysis perform better for change detection to other methods.**

Keywords— Landsat8 images; Preprocessing images; image differencing; principal component analysis; change vector analysis; Post classification; Accuracy assessment.

I. INTRODUCTION

The remote sensing is very important part of the change detection techniques. The change detection techniques used in the informed environmental information and agriculture field. Change detection is the process of identifying difference state of an object or phenomenon by observing it at different times. The time and accuracy of change detection on the earth's surface can provide a better understanding of the relationship and interaction between human and natural phenomena. Change detection quantifying the temporal effect using multi-temporal data sets. The various application are involve in change detection technique like deforestation, urban development, damage valuation, scourge monitoring, and planning and land disposition[1].

The change detection methods are mainly categorized as classification based or spectral based. If the source of noise are properly reduced in spectral based method, major changes in the Earth's surface during different periods can be assessed by the ground reflection. The pixel based methods include image differencing and change vector analysis (CVA) while principal component analysis is transformed based method of Change detection. Classification based methods such as post classification comparison methods and two date image clustering specify the occurrence of changes in image pixels and label them.

Various methods have been proposed to detect changes captured by satellite images. The Algebraic methods like image differencing is relatively simple and easy to understand and can be easily implemented. The disadvantages of these methods are in choosing an appropriate threshold. However, this method does not extract details of the changes completely. CVA determines the direction and magnitude of changes by computing the Euclidean distance between the start and end point of a change in n-dimensional space. The CVA method requires more accurate accuracy then other methods; the advantages of this method are the greater information extraction compare to other methods. Transformation methods focus on reducing the data between bands, and value different information in derived components. In this method is in detecting the changes based on reliable details and reducing the atmospheric and environmental effects on the data [3].

The objective of this paper is to identify changes of Alaska in USA through the period from 4May, 2014 and 20 May, 2014. There are several methods are used to identify changes using remotely sensed data. In this study, three change detection techniques were applied to detect changes in river fire on a south-central Alaska, USA using landsat8 multispectral images. These techniques are: (1) image differencing, (2) principal component analysis(PCA) and (3) change vector analysis and to compare their efficiencies with post classification method and carry out accuracy assessment for different methods. Algorithms were coded in MATLAB environment.

II. STUDY AREA

The land area considers as a Funny River Fire in Alaska, USA. It lies between latitude -151°51' and -150°49 ' N and longitude 60°46 ' and 60°18 ' E. The Funny River Fire was discovered on May 19, 2014, it had burned almost 200,000 acres in south-central Alaska, including much of the Kenai National Wildlife Refuge. The Landsat8 image on May 4 shows the area before the fire began. Heavy smoke covers the Kenai Peninsula in the May 20 image, and this image also

shows some of the areas of active burning along the edges of the wildfire area. Using this study area was carried out using temporal satellite images of Landsat8 taken on 4 MAY, 2014 and 20 MAY, 2014.

III. METHODOLOGY

The methodology used for analysis of different change detection methods using satellite images is divided into five main parts as shown in fig.1. The method involves processing of landsat8 images that are detecting the change in study area images. The image processing techniques using first preprocessed the images then image processing is used for different change detection algorithms and to compare their efficiencies with post classification method and carry out accuracy assessment for different methods. The block diagram of proposed system as shown in figure 1.

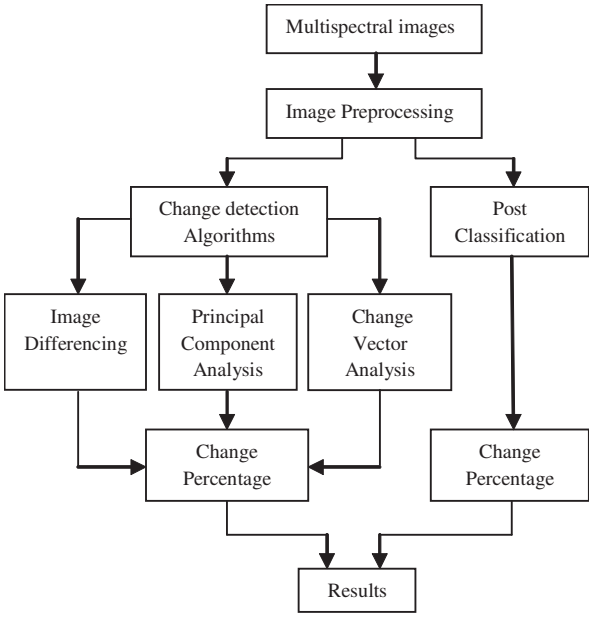


Fig.1 Block diagram of Change Detection System [2].

A. *Image Preprocessing*

Basically the image pre processing operations using image restoration and rectification. This is the intended to correct for sensor and platform-specific radiometric and geometric distortions of the data [4]. In this work, the images are transformed into gray scale image for processing. Also for ease of computation image is resized and then filtering this image using Median filter.

B. *Change Detection Algorithms*

The pre-processing stage was completed then after three different change detection algorithms are applied to the images first is the image differencing, second is principal component analysis and third change vector analysis. The first and third are pixel based methods and second is the transformation based methods of change detection.

1) Image Differencing :

Image differencing is very intelligible method of the change detection techniques. It is applied to a wide variety of the images and geographical data. It is generally conducted on the basis of gray level images. A subtraction of the two images is gain into the gray value of corresponding pixels after image registration[2]. The changed and unchanged area is determined by selecting the appropriate threshold values of gray level subtraction image as show in figure 2.

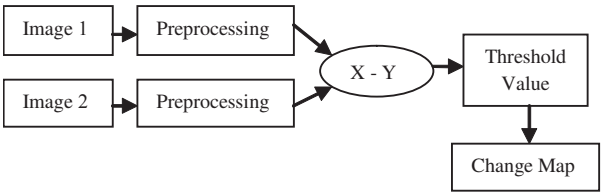


Fig.2. Block diagram of Image Differencing

Mathematically,

Difference image, $D(x) = I_2(x) - I_1(x)$ (1)

Change mask, $B(x) = 1$ if $|D(x)| > T$

0 otherwise (2)

Where,

I_1 & I_2 = images from time t_1 and t_2

x = coordinates of each pixel value

D = difference image

The subtracting these two images are selects the threshold value then deciding the capability of change detection. Choosing this suitable threshold value can be maximum separated for the areas of real change then this positive or negative value of images is denoted by the radiation value is changed and the image value is 0 in the region of no change. In these 8-bit images the pixel value range from 0 to 255 and its image subtraction value range -255 to 255. Suppose the subtraction value is often negative then it can add a constant C. The luminance values of the subtracting two images using approximating of Gaussian distribution. Hence, this distribution using the unchanged pixels value is centralizing around average value and the changed pixels value is in the distribution of the tail [10].

2) Principal Component Analysis:

The principal component analysis is linear transformation base technique. The main principal of the principal component analysis approach is use to input a set of images and to reorganize them via a linear transformation, such that this output images is linearly independent then new coordinate system of the data is the biggest variance lies on the first axis in the first principal component and the second biggest variance on the second axis. This technique is reducing the number of spectral bands and in compression scheme. The value of linearization is the unchanged pixels or common information shared by a pair of images [11]. The first component image is containing the no change pixels image

whereas the second component image is contain the change information between the different dates [2].

Principle component analysis also referred to as eigenvector change, Hovelling transformation and Karhunen Loewe transformation in main part of remote sensing. This method is a multivariate method that is used to reduce dataset dimensionality. In this method, the original dataset is a correlated variable; this is transformed into simpler dataset for interpretation. This datasets allow to the uncorrelated variables representing the information from the original data and then calculate of the variance-covariance matrix (C) of multiband images is expressed as: where M and X are the multiband image mean and this individual pixel value vectors respectively and n is the number of pixels. In change detection technique, there are two ways to apply PCA. The first type is adding the two dates images into to a single file, and the second type is the subtracting the images from second date image into the first date image then performing PCA separately as show in figure 3.

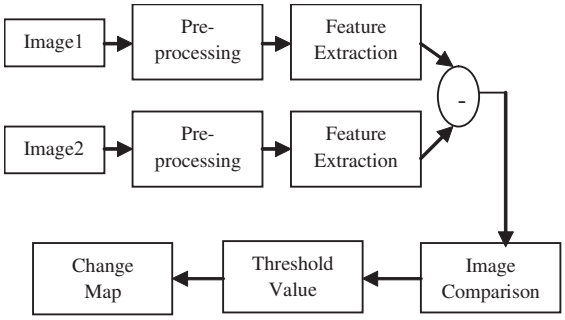


Fig.3 Block diagram of Principal Component Analysis

Steps for implementing PCA algorithm:

1. Firstly to get some data.
2. Then subtract the mean of data.
3. Calculate the variance matrix.
4. Calculate the covariance matrix.
5. Calculate the eigenvectors and Eigen values of the covariance matrix.
6. Choosing components and forming a feature vector.
7. Deriving the new data set.
8. Getting the old data back.

3) Change Vector Analysis:

Change vector analysis is a change detection tool that characterizes dynamic changes in multi-spectral space by a change vector over multi-temporal imageries. The basic concept of CVA is derived from image differencing technique as show in figure 4.

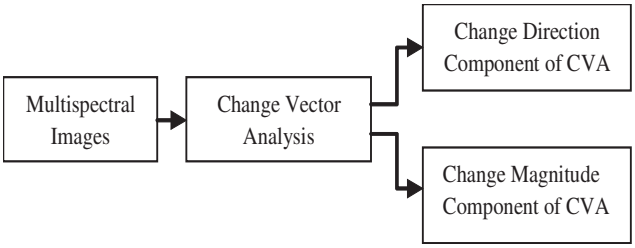


Fig.4 Block diagram of CVA [8].

The change vector analysis involves two variables, the magnitude of variation and the angle of the change vector. The change vector is obtained by subtracting the images represented in vector form. NDVI (Normalized Difference Vegetation Index) and BI (Bare Soil Index) are the two indices that need to be calculated in Change Vector Analysis method.

$$NDVI = (NIR - RED) / (NIR + RED) \quad (3)$$

$$BI = ((SWIR + RED) - (NIR + BLUE) / (SWIR + RED) + (NIR + BLUE)) \quad (4)$$

Where,

NIR, RED, SWIR and BLUE are the spectral reflectance measurements acquired in the near-infrared, red, and short wave infrared and blue regions. The concept of CVA is represented in figure 5.

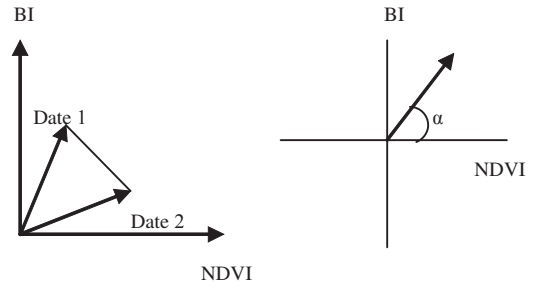


Fig.5 Concept of CVA [6]

Change vector of each pixel includes two components NDVI and BI, which are the 2 axes in Cartesian coordinate system. The start point and finish point of the change vector are the locations of pixel in NDVI-BI space of Date1 and Date2 images. The change vector magnitude is represents the change intensity and the change vector direction is represents the change dimension [2]. The magnitude of change vector is notated that S and direction of change vector is notated that α are obtained by the following equations:

$$S = ((NDVI^2 - NDVI^1) + (BI^2 - BI^1))^{1/2} \quad (5)$$

$$\tan \alpha = (BI_2 - BI_1) / (NDVI_2 - NDVI_1) \quad (6)$$

Where,

S = length of change vector means Change intensity,

α = change direction means Nature of land cover change.

NDVI1 and NDVI2 = digital number of each pixel in the NDVI image at date 1 and 2,

BI1 and BI2 =digital number of each pixel in the bare soil index image at date 1 and date2.

Steps for CVA Algorithm:

1. Threshold Selection
2. Calculating the indices and the change
3. Determining the level of change

4) Post Classification Change Detection:

The last most important method in change detection namely post classification method. In this method to carry out the overlay of two or more classified images. The change area are simply those areas which are not classified the same at different time. The post classification comparison methods are one of the most widely used methods of remote sensing change detection technique. This post classification change detection are used to the cross classification to determine the 'from-to' changes[4]. This is enabled assessment of the three algorithms. In this study area is depict into the three land cover types are consist of water body, vegetation and barren land. Table.1 gives the comparative study for the area covered by different land cover classes after doing post classification.

TABLE I. AREA INFORMATION

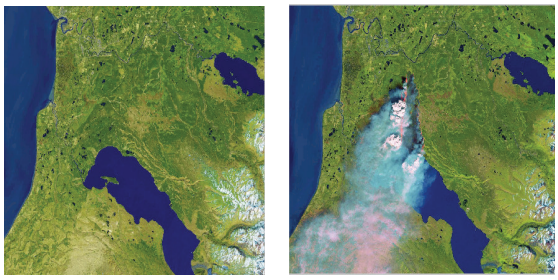
Class Name	4May,2014 area in m^2	Area in %	20May,2014 area in m^2	Area in %
Water body	352345	20.49%	305179	17.75%
Vegetation area	1251471	72.78%	996216	57.93%
Barren land	115784	6.73%	418205	24.32%
Total area	1719600	100%	1719600	100%

IV. EXPERIMENTAL RESULT

By implement change detection methods using different approaches, below results shows output of different approaches change detection images and show the percentage of change area in each approaches:

a) Original images:

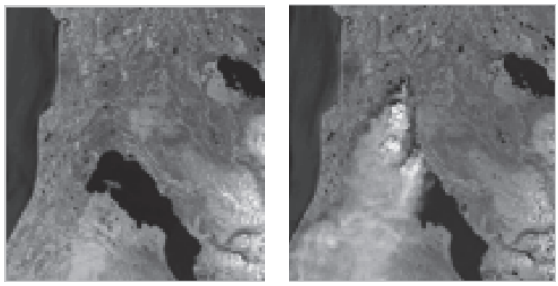
Original image1 Original image2



(a1) (a2)

b) Gray scale images:

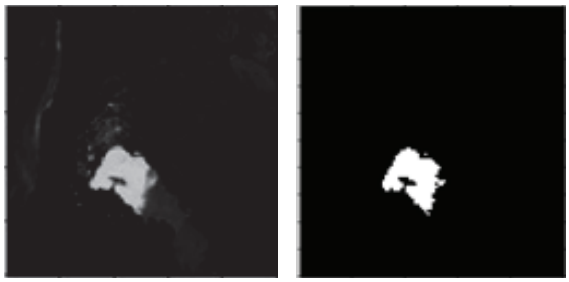
Gray Scale image1 Gray Scale image2



(b1) (b2)

c) Image differencing method:

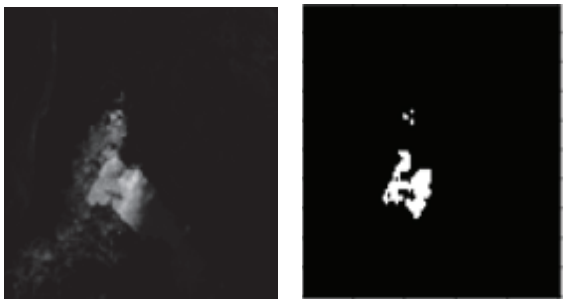
CDID Binary CDID



(c1) (c2)

d) Principal component analysis method:

CDPCA Binary CDPCA



(d1) (d2)

e) Change vector analysis method:

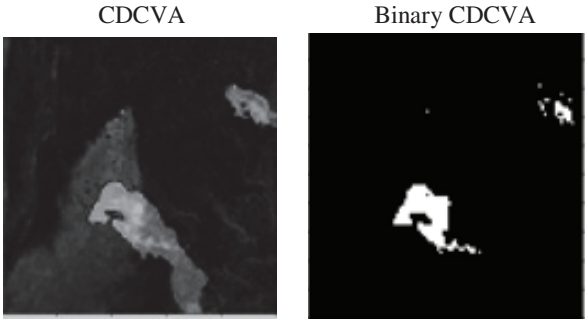


Fig.6 (a1)&(a2) Original images, (b1)&(b2)RGB images converted into gray scale images, (c1) Result show image differencing change detection&(c2) image convert binary image, (d1) Result show principal component analysis change detection&(d2) image convert binary, (e1) Result show change vector analysis change detection&(e2) image convert binary

TABLE II. CHANGE PERCENTAGE IN DIFFERENT CHANGE DETECTION METHODS

Methods Name	Change Area	Change Area in %
Image Differencing	291	0.017 %
Principal Component Analysis	201	0.012 %
Change Vector Analysis	303	0.018 %

V. CONCLUSION

This paper presents Analysis of the various change detection techniques using satellite images. It is very useful for detecting the change at specific study area. In this paper changes detection technique used to compare the changes occur in River Fire area along south central Alaska, USA. All of the processes were performed using landsat8 satellite images from two different dates 4 May 2014 and 20 May 2014 with the assistance of enhanced thematic map per. This methodology updates the change detection of the particular area every eight days. This objective can only be accomplished by highly automated processes and minimum manual interaction.The Result obtained from to study area clear show that the change vector analysis perform better for change detection to other methods.

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