Research Paper Engineering

Comparative Analysis of Various Change Detection Techniques For Hyperspectral Images

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ABSTRACT

HYPERSPECTRAL remote sensing images provide highly detailed information on spectral changes so as to offer promising performance for change detection. It is an advancing technology with a wide range of applications. Change detection is the process of automatically analyzing the regions which are undergone some changes over specific time interval such as spatial or spectral changes. Discovering abnormalities in medical diagnosis, target reorganization, environmental conservation, urban planning, etc. are some of the relevant areas which make use of this.

This paper analyses various traditional as well as emerging techniques that efficiently detect changes in the images of same scene taken at different times and explores the suitability of each method for respective areas. This paper presents a review of mechanisms involved in various kinds of change detection techniques, their individual requirements, limitations, features and area of applications.

KEYWORDS : Independent component analysis, Object Based Change Detection, Synthetic Aperture RADAR.

INTRODUCTION

Change Detection:

Change detection is the technique of identifying and analyzing deviations in the state of an object or phenomenon it has undergone, by observing it at different times. In numerous applications, change detection using remote sensing has played an important role. Remote sensing is the acquisition of information about an object or phenomenon without making any kind of physical contact with that object. Remote sensing technology provides a large-scale view of landscape over long time period and has been demonstrated to be an efficient method for change detection.

1.2 Traditional Techniques for change detection:

Existing change detection techniques are broadly classified into two categories

1.2.1 Unsupervised approaches consider the raw multispectral images only, to generate further image. Pre-processing is performed to make the input images compatible, and then these processed images are compared according to individual features. Here output is not predictable.

1.2.2 Supervised approaches make use of several training sets for learning purposes. This allows easier statistical estimation of the kinds of changes occurred. This results into an advantageous approach since it can process images from multiple sources and is robust.

1.3 Latest Techniques for change detection:

The advent of high end processing systems and enhanced algorithms has led to the implementation of newer change detection approaches like (OBCD). The change detection techniques have also been developed for SAR & 3-D images.

BASIC PRINCIPLE OF CHANGE DETECTION

In mathematical terms, change detection algorithm analyses an input image sequence given as {IMG1, IMG2,…IMGn} where n indicates the number of images and generates a difference image Df, where:

Df(i) = 1; if there is a change in the ith pixel
0; otherwise

Here each pixel (I) has an intensity I(i) ϵ Rj, where j depends on image type, for e.g. 1 for grayscale images, 3 for RGB images or more for SAR images. For a specific problem, a wide range of factors affects the results of change detection which often leads to difficulties in selecting the most suitable technique. These factors include good quality of input data, geometric registration, cost and time limits, normalization etc.

OUTLINES OF VARIOUS CHANGE DETECTION METHODS

The various image change detection techniques can be classified as shown on the next page in fig 1.

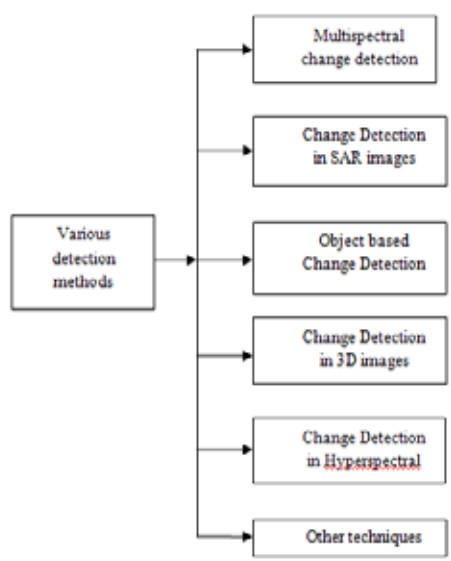

Fig 1: Various change detection techniques

Multispectral Change Detection: - These change detection techniques consider spectral, spatial, thematic and temporal constraints. The spectral information offered is not so elaborate by multispectral data. Several techniques which fall under this category are like spectral– temporal combined analysis, ANN, hybrid change detection, and maximization algorithm (EM) change detection.

Change Detection in SAR Images:-

SAR is a kind of microwave imaging radar that can be used in all weather conditions for remote sensing. SAR data are satellite images which are captured by these SAR devices mounted on satellites, space aircraft. Examples: Change Vector Analysis (CVA), image differencing K-means clustering, Multivariate Alteration Detection (MAD) etc.

Object Based Change Detection (OBCD):-
OBCD technique is more suitable for images having high resolution in which it processes a set of pixels as a single object. Here the basic feature is the extraction of objects through segmentation and then processing them as homogeneous units. Examples: Genetic Algorithm based object-oriented method for High-Resolution Images, Objects Based Change Detection in a Pair of Gray-Level Images etc.

3.4Change Detection in 3D Images:-
The techniques come under this category are as follows- City-Scale Change Detection in Cadastral 3D Models, change detection by 3D voxelbased model, Detecting geometrical changes in urban locations etc.

3.5Change Detection in Hyperspectral Imges:-
For hyperspectral data, the presence of real change is indicated by the change of a spectral signature from one material to another material. Hyperspectral images offer more abundant and highly detailed information on spectral change in multitemporal scenes, which can improve the performance of change detection.

3.6 Other Techniques:-
Certain researchers have focused more on developing techniques that address such issues like like choice of threshold, misregistration faults etc

3.6.1 Patch-Based Markov Models for Detecting changes (P´ecot and Kervrann 2007) *3.6.2 Sub Pixel Change Detection*- An a contrario Approach (Robin, H´egarat-Mascle and Moisan 2009)

LITERATURE SURVEY:-
The overview of certain principle research studies on Change Detection can be concluded as follows:

Hyper-spectral Change Detection in the Presence of Seasonal and Diurnal Variations
This work has explored the space-varying nature of such kind of changes through empirical measurements and also investigates spectrally segmented linear predictors for accommodating these effects. Several specific algorithms has been developed and the impacts on clutter suppression are quantified and compared.

Spatio-Spectral Anomalous Change Detection in the Hyper-spectral Imagery
James Theiler have discussed that to exploit the evident spatial structure of pixels, one way is to incorporate spatial processing in to pixel-wise algorithms for anomalous change detection. But if this is done in a straightforward way, a contaminated cross-covariance is produced. A framework is proposed that avoids this contamination.

A change detection method based on sub space for hyper spectral image
Chen Wu proposed a sub-space based (SCD) method for detecting hyper-spectral images change. This method takes the observed picture element (pixel) as target in the Time2 image and builds the background subspace by using the corresponding picture element in Time1 image and by using the additional information.

A Valuable approach on SAR data for Image Processing and Change Detection
In order to detect change on SAR images they used PCA technique which involves Singular Value Decomposition Method (SVD) method to process the images. After that they compared the images pixel by pixel and find out the changed pixels and map those pixels to display the changed map.

Enhancement of ICA Algorithm
By ICA algorithm, the environmental changes in multi-temporal remote sensing images can be detected in reduced second and higher-order dependencies. This can remove the presence of any correlation among multi-temporal images without any prior knowledge regarding change areas.

ICA Performance analysis Using Tuning Parameters Size
The goal of this work was to offer such an improvement in ICA by introducing specific tuning parameters in FastICA algorithm. The better performance of ICA for removing the correlation efficiently among the various components found from the given hyper-spectral data has been assured by experimental results

SUMMARY OF VARIOUS CHANGE DETECTION METHODS
The following table contains all change detection methods that are explained previously and also contains the basic principle and mechanism of each method, their features, on which the particular method is based, their requirements along with the areas of applications they are/can be used in.

The table containing all these is shown below:
Table 1:- Comparison of various change detection techniques

Technique Name	Author & Year	Mechanism	Requirements	Features	Applications
Univariate Change Detection	Skole and Tucker (1993)	difference is done pixel by pixel	Threshold determination	Disadvantage:- Do not know what has changed (from-to)	Used to detect deforestation in Amazon
Image Ratioing	Zhang Shaoqing, Xu Lu (2008)	The ratio of the DN values for a stable feature over two dates would be unity	thresholdValue determination to differentiate no-change/change, i.e. often empirical	No from-to information on change detection is available	detecting changes in urban areas
Image regression	Murat ilsever, Cem Unsalan (2012)	values of pixels at date1 is assumed to be linearly related to those at date2. A linear relationship is built up	The values of pixels from date 1 to date 2 is needed to be calculated	Calculation of difference between the value from prediction and real date2 value	a no-change/change map can be generated
Technique Name	Author & Year	Mechanism	Requirements	Features	Applications
Change vector Analysis (CVA)	M.Hussain(2013) Sartajvir Singh(2014)	Reflectance values collected for a pixel can be taken as vector coordinates in a multi-dimensional space	vector difference between two dates	Difficult to identify land cover change trajectories	Change measurement in 2ways, magnitude & direction of change
Principal Component Analysis (PCA)	Vijay Kumar (2013	Uses an images set as input and reorganize them through a linear transformation, such that the output images are linearly independent	Data is projected so that the greatest variance lies on the 1st axis and the 2nd greatest variance on the 2nd axis	Can reduce noise effect, like atmospheric	Easily classify changed and unchanged areas
Independent component Analysis (ICA)	Vikrant Gulati (2014)	Linearly transform the data in a way that transformed variables are independent	concerns with higher-order dependencies also	Better removal of correlation among components	Extract some thematic information in advance like water bodies, vegetation,

CONCLUSION:

We have analyzed the various traditional and latest techniques that have either been proposed or implemented for change detection in images. Selection of a technique that provides best results for a particular application is always a challenging task owing to continuously varying nature of images, weather conditions and angle of capturing, accuracy requirements etc. Hence a good knowledge about the underlying techniques is required to select a suitable method depending on the project in hand. The analysis given in this paper can prove handy for helping in proper selection of technique to be used for change detection as per the specifications of problem in hand.

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