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A Review of Change Detection Techniques of LandCover Using Remote Sensing Data

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Abstract:*This paper goes to provide an overview of various techniques used for change detection of landcover with conventional and object based techniques. Now days, progression in remote sensing technologies has become a great encouragement for the researchers to analyze various changes in landcover to maintain the environmental balance on the earth surface but due to some addressable issues, it is relatively difficult for researchers to choose one most effective technique.Change detection techniques are having various limitations of extent of defining changes, correctness of classification maps to point out the variations and so on. Therefore several methods have been modeled to prove their effectiveness and accurateness in context of change detection. This paper starts with illustration of prime issues in change detection procedure; review the elementary techniques of change detection followed by the recent object oriented methods for change analysis. Study highlighted the technical soundness of the demonstrated approaches.*

Keywords:*Change Detection, Forest monitoring, Object-oriented,Remote sensing data*.

I. Introduction

The surface of earth is changing day by day that is a matter of great concern for researchers to device strong methods that able to identify the various fluctuations on earth surface at various temporal and spatial scales.The prime necessities of researchers to build robust techniques for change analysis are the truthful and constantly updated data so that through appropriate statistics changes can be analyzed and various recommendations can be offered. Until now we were dependent on the visual interpretation of ground truth information and some obsolete conventional methods to demonstrate the landcover changes but now new automated systems have changed the scenario of the research and latest cutting edge object based techniques brings theconcept of automation and rapidity. In 1972 Landsat-1 has been launched which manifest the inauguration of satellite remote sensing for various applications. Satellite centered sensors hold the aptitude to spot the variations systematically and consistently over time due to their snottyand repetitive data acquisition abilities.The constant observation of land cover is required to provide the information on various changes on earth surface and especially define the unit of interaction among various phenomenon provides the basis to use natural assets in a more better way [1]. Basically the idea of change detection has been defined as 'the process of identifying differences in the state of an object or phenomenon by observing it at different times', delivers a means to understand the phenomena and related concepts of change detection [2]. However the updated knowledge base about changes in surroundings is very essential to demonstrate the latest trends of specific changes that would help in designing goal-oriented techniques for change analysis.

The viability and accuracy of various change analysis methods have been explored in past three decades for different purposes [1, 2, 3].Conventionally, pixel based change detection techniques consider single pixel as their basic elements of change analysis but recentlywith the arrivalof effectual image analysis algorithms that integrated the change analysis systems with various segmentation and feature extraction capabilities from satellite imagery, which in turn facilitatenovel functionalities. The new developments in the field of image analysis introduced most influential object based change detection approach which has evolved from the concept of object based change analysis [4, 5]. This technique considers the group of pixels as its basic unit of functionality. Basically image analysis process begins with elementary segmentation step which cut the image into desired pieces called image objects followed by various classification processes to identify variations in the study area. The development in the field of remote sensing technologies has increased the demands of users for accurate and timely change detection information that remain compatible with different platforms.Change detection is useful in many applications such as land use changes, habitat fragmentation, rate of deforestation, coastal change, urban sprawl, and other cumulative changes. The various challenges of selection of appropriate method, data and study of their limitations still need to be addressed.

II. Considerations In Change Detection

Many factors ruled the accuracy of change detection procedure using satellite images. Moreover, there is not a single technique of change detection that has claimed to be suitable for all scenarios. Each method has its own pros and cons that must be taken under considerations.There are various issues needs to be understand while performing change detection, as these issues actually going to affect the accuracy of change detection method.

2.1 Image acquisition

The most crucial step in the change detection pre-processing is the selection of appropriate data registration dates so that variations and erroneous results can be avoidedin order to increase the interpretability of the outcomes as same geographic objects are compared at different points of time [6]. The choice of desired algorithms, sensors, spatial scale and temporal scale are also very important factors to consider. These factors also affect the performance of image acquisition and it has been proved that in a particular image, finer spatial resolution enhance the effects of misregistration on change detection accuracy [7]. Basically spatial scale defines the size of pixel [8] moreover corresponds to the view window of the scene [9, 10]. At a very important node it has been considered that satellite imagery with low resolution are able to observe the environmental flux precisely over large geographical area but several difficulties are encountered in case of mixed pixels to mark the variations efficiently. However, interested image objects can be outlined from high-spatial-resolution images more efficiently but with possibility of creation of fake alterations.A further note on high resolution is that with it, it is more difficult to perform an accurate image registration than by using low resolution, resulting in a decrease of change detection accuracy.

The concept of image acquisition is also influenced by the temporal scale which corresponds to the time gap between consecutive acquisitions of the desired site images from same geographic location [11]. Temporal scale is also term as temporal resolution. Several time it has been argued that what kind of images would be suitable for what kind of region and what would be the correct temporal scale to analyze the differences in that area. In order to tackle such kind of difficulties analyst first clarify the research objective and then go for other factors to get expected outcomes.

2.2Viewing geometry and Radiometric correction or normalization

During acquisition of satellite images, there are several factors works to affect the reflectance value of image objects on the surface of earth such as the value of angle, means at the time of image acquisition what is the value of angle has been chosen. Basically in ideal situation sensors remain at nadir position so that top view of the images can be captured but these sensors may tilt accordingly to capture the detailed view of the desired objects as Quickbird can tilt up to 20 degree [12]. Furthermore, spatial resolution of a particular object is a significant aspect to consider which is decreased by the different look angles of the sensors in order to collect more views of that object whereas sun angle is equally important to affect the reflectance of the objects at different locations. Therefore, it has been suggested that same sensor angle should be selected in order to collect the object information for change detection [12].There is one more factor calledRadiometric correction which is also responsible for checkout of the changes as multidate data used for the process of change detection as it could be the possibility to occur radiance dissimilarities due to atmospheric turbulences and senor's improper working. In order to improve the accuracy of change detection process, different complex radiometric calibration improvement algorithm not even achieve the target and therefore relative radiometric correction has taken into consideration to standardize the images bands intensities.

III. Change Detection Techniques Classification

It has been claimed by the researchers that it is very difficult to observe earth surface corresponding to the changes with satisfactory results [13]. Therefore, so many methods or algorithms have been explored as well as modified with fast changing remote sensing technologyto notice the changes on earth surface. Basically, change detection techniques have been divided into two categories that is pre-classification and post-classification change detection [14, 15]. The techniques that comes under pre-classification category, just extract minimal information about changes whereas post classification techniques separate changes in detail way with appropriate attributes [16, 17] but have some limitations of not detecting subtle changes within land cover classes [18].Here, we tried to describe as many as methodologies including latest object oriented change detection methods. All methods are equally important and possess their own strengths and weaknesses.The general structure of the change detection procedure is depicted in fig 1 and several categories of the change detection have been tabulated in table 1.

Monotemporal Change Delineation outlined the change detection algorithm using pattern recognition module which acts as functions for it. Existing records are the basis of this approach to represent the condition of interested area before destructions. Delta classification technique individually creates results of spectral

extraction in timely manner, complete change matrix is achieved through separate comparisons of pixels and segments and finally changes can be defined. This method comes under post-classification category and advantageous in avoiding radiometric calibration problem of multi date data. Initial classifications are very important as it determine the accuracy of delta classification. Appropriate classification method selection can particularize the abrupt changes in desired area [19].Unsatisfactory results can be obtained using delta classification due to misclassification and misregistration errors [17]. The most effective algorithm for natural environments is multidimensional temporal feature space analysis to identify the tiny changes but analyst complained about its less information providing nature about changes [15]. This method uses the concept of image overlay for pixel enrichment to define the changes. Composite Analysis is a complex method due to addition of data from two different dates. In this method, combined registration of image data can create confusion or provide confusing change information where the final decision is based on the decision of each stage. Image Differencing is robust, easy and most commonly applied algorithm for change detection for different geographical conditions [2] but requires atmospheric calibration and its same value may represent ambiguous meaning. Basically, subtraction is the main theme of this method as it subtracts the date 1 image from date 2 image to create change matrix where positive and negative value means change occur in study area and zero means no change occur in that particular area.

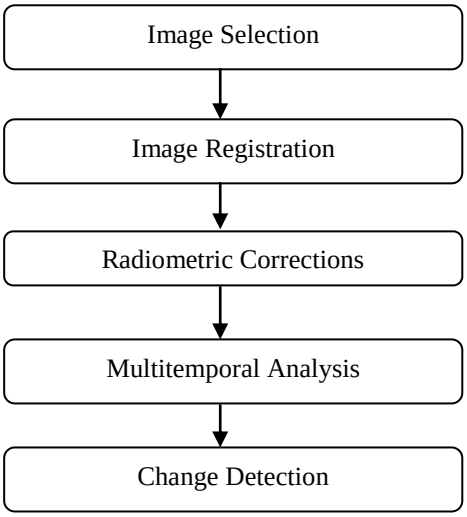

Fig 1 Change detection procedure

The concept of Image Ratioingcircled around threshold value chosen for change, it is simplest, fast but may encounter with viewing geometry aspects. The value of ratio is defined by the pixel analysis as unchanged pixel yield one ratio value and change areas yield ratio value higher or lower than one**.**Multitemporal linear data transformation techniques can be successfully applied to data sets from different dates that piled in two different n-dimensional space where n represents the number of bands comprises in a particular image. Principal component analysis and tasseled cap are the examples of this technique that are able to find out the minor transformations in the forest area. Even recently generalize version of tasseled cap has been developed to improve the functionality of the underlined method [20].Change vector analysis has been considered as the first automated method to mark the variation. This method produces direction and intensity image of particular changes where direction image is responsible for detecting change. Moreover, it combines the tasseled cap transformation and tries to catch the movement of different segments derived from the image in n-dimensional spectral space in the form of direction and magnitude [21]. It is used in the situation when detailed change information is required.Image Regression technique makes use of powerful regression function to establish the relationship between pixel values of multi-date images where changes indicated by the dimension of the residuals. Furthermore, this technique avoids atmospheric influence and is not able to present change matrix**.**Multitemporal Biomass Index method was developed for forest monitoring but it is not able to fulfill the objective. Background Subtraction techniques were used for observe the deforestation in tropical region. But the use of both methods was limited as results was not that much efficient and useful [2].

In continuation, some object based change detection algorithms also have been reviewed in order to highlight the recent advancement in remote sensing field. Image-object change detection algorithm utilize threshold value in order to compare image-objects like pixel based algorithms perform operations pixel-by-pixelto determine the exact changes. Spectral values are responsible to analyze the changes in segmented imagery and direct image comparisons are accentuated in these algorithms.A class-object change detection

algorithmclassifies different objects from multi-temporal data independently to determine the detailed variations where texture and spectral features of the objects are not considered. There are several factors such as viewing geometry, atmospheric attenuation and so on that can affect the originality of the geographic feature while areas remain same but at different dates [21].Multitemporal-object change detection algorithm combines sequential images of same place but taken at different point of time to segment and determine corresponding geographic changes in the scene.Hybrid change detection algorithmsarea kind of unique category that make use of pixel and object phenomenon and the concept behind this strategy is that pixels derived the initial changes that further refined by the object criteria for better understanding of the results.

Table 1.The seven change detection technique categories

	Techniquecategories	Example of techniques
1	Algebra Based Approach	• Image differencing • Image regression • Image ratioing • Vegetation index differencing • Change vector analysis
2	Transformation	• PCA • Tasseled Cap (KT) • Gramm-Schmidt (GS) • Chi-Square
3	Classification Based Post-Classification Comparison	• Spectral-Temporal Combined Analysis • EM Transformation • Unsupervised Change Detection • Hybrid Change Detection • Artificial Neural Networks
4	Advanced Models	• Li-Strahler Reflectance Model • Spectral Mixture Model • Biophysical Parameter Method
5	GIS	• Integrated GIS and RS Method • GIS Approach
6	visual Analysis	• Visual Interpretation
7	other Change Detection Techniques	• Measures of spatial dependence • Knowledge-based vision system • Area production method • Combination of three indicators: vegetation indices, land surface temperature, and spatial structure • Change curves • Generalized linear models • Curve-theorem-based approach • Structure-based approach • Spatial statistics-based method

IV. Conclusions

Monitoring of earth surface is possible with the wide range of multi-source remote sensing data and feasible techniques to observe the alterations. There are lot of methods have been evolved in past decades and these methods also succeed to produce quality results but automation, cost , time and accuracy is the real challenge that needs to be meet. In past decade, new object-based techniques have been introduced to overcome the mentioned shortcomings and up to some level these techniques meet the goal of generating satisfactory outcomes of change detection with great potential but it does not mean conventional methods are useless, they are also useful in other context. Object-based methods are highly recommended due to their efficient nature in presenting detailed change information. The potential of this paradigm can be incorporated with reconsideration of conventional methods to increase the functionality and it is possible to use both methods simultaneously to produce results with better precision.This is a wide area of research; all the methods we have discussed above have great potential and promising capabilities in the field of change detection but still have lot of scope to develop innovative techniques and methods in order to get effective results of change detection.

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