Al-Sibd Center
for Research and Scholarly Publishing

Iraqi Journal of Natural Sciences and Nanotechnology IJNSN

A Matlab-Based Graphical user Interface for Change Vector Analysis in Land Cover Change Detection using

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Keywords:

Change Vector Analysis; Remote Sensing Images; NDVI; BSI; Spectral Reflectance Threshold;

Abstract

Earth's land surface is continuously reshaped by both natural processes and human activities. Accurately detecting these changes in the a timely manner is essential for understanding the complex interplay between human actions and natural phenomena supporting informed decisions in environmental management and resource planning. Change detection methods quantify these temporal variation by analyzing multi-temporal datasets from Earth observation Satellite which provide consistent image quality and regular revisit intervals. Change Vector Analysis (CVA) represent a robust approach for characterizing land cover dynamics, however there are n standardized software packages are available, it may require repetitive manual implementation of algorithms for each image pair, making the process inefficient. This study addresses this limitation by making an integrated learning platform through a Matlab-Based Graphic User Interface. The application utilizes fundamental Matlab function for threshold determination and CVA implementation. The primary advantage of this tool lies in its accessibility and user-friendly design, enabling extraction of critical information including optimal threshold values. BIS and NDVI change vectors directional change and transformation characteristics.

Introduction

Change detection is a systematic process of identifying changes in feature or phenomena by observing them at different times. This analytical is used across many fields including Land use and Land cover assessment shifting cultivation monitoring , vegetation phenology , damage evaluation , crop stress detection , diurnal thermal pattern analysis and broader environmental change studies. As remotely sensed data form satellites and airborne platforms becomes increasingly sophisticated. The field continues to evolve requiring ongoing development of new detection Methods.

There are only two primary kinds of the Remote Sensing technologies, the passive and the active system. The passive sensors capture naturally emitted or reflected radiation form Earth's surface with reflected solar radiation being the dominate energy source. Active sensing systems emit their own energy and measure the radiation reflected or backscattered from the target features . The foundational principle of change detection using remotely sensed data are that alterations in land cove produce detectable changes in spectral radiance values so, change that must clearly exceed variability introduced by confounding factors like atmospheric conditions the solar angle shifts and soil moisture levels [1].

While these external influences can't be eliminate entirely the effects can be mitigate through strategic data selection using anniversary date imagery for instance reduces variability tied to solar angle and phonological timing. Numerous digital change detection approaches have been established for land cover monitoring such as post-classification comparison.

The Multidate classified images difference and ratioing vegetation index difference , principal component analysis and change vector analysis [2 , 3]. Geometric correction algorithms are necessary for accurate spatial co-registration of multi-temporal images aligning them either mutually or to a standardized map projection. Most techniques additionally require threshold determination to distinguish actual change areas form spectral variations attributable to other factors [4].

Foundational Principles of Remote Sensing Data Processing
The technology of Remote Sensing is grounded in the principles of inverse problem solving although the phenomenon or feature under investing can't be directly measured observable variables and the measurements themselves can be detected the quantified and subsequently related to the target parameters via computational models derived from the data. Data quality in remote sensing are characterized by four essential resolution types spectral , spatial , temporal and radiometric [5].

The Nature Spectral Reflectance
Spectral reflectance refers to proportion of incident radiation on that a surface reflects. Because reflectance is directional its value depends on illumination, geometry , wavelength and viewing angle. The hemispherical spectral reflectance is given by :

$$\boldsymbol{\rho}(\boldsymbol{\lambda}) = \boldsymbol{Gr}(\boldsymbol{\lambda})/\mathbf{Gi}(\boldsymbol{\lambda})$$

Where; Gi(λ) and Gr(λ) represent incident and reflect spectral intensity. Integration across wavelength with specific bands yields the factor of total hemispherical reflected:

$$P = Gr/Gi$$

Spectral reflectance knowledge facilitates atmospheric contribution assessment as it allows direct comparison between instrument measured reflection and actual spectral values. This methodology can be extended to infer unknown target reflectance by leveraging reference targets whose spectral properties are already established [6].

NDVI And BSI

Change vector analysis depends on two fundamental indices. The first are NDVI that exploits the differential reflectance of chlorophyll in red and near-infrared wavelengths serving as an indicator of biomass vegetation productivity and fractional cover. The second BSI are distinguishes agricultural from non-agricultural land by incorporating shortwave infrared information
The developed MATLAB GUI enables users to select two dates of imagery from a dropdown menu, accessing Blue, Visible Red, Near-Infrared and Shortwave Infrared band information. Visualization options include Color Infrared (CIR) composites, NIR versus red scatter plots, and threshold NDVI displays. The interface employs MATLAB's UI controls with fundamental image processing functions.

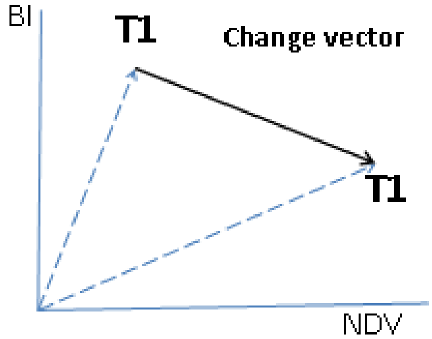

Figure 1: NDVI change

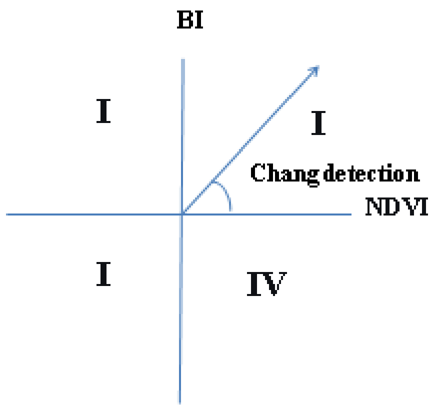

Figure 2: BI change

Methodology

Threshold Determination

Optimal threshold values are determined through an iterative approach. An initial threshold is estimated from background pixels located in the image corners where each corner is defined as one-tenth of the image dimensions. The mean gray level of these corner regions provides the starting point. From there, the object mean gray level is calculated and threshold-based segmentation separates object from background . This procedure repeats using background pixels, updating the threshold as the average of object and background means. Iteration continues until threshold convergence. Alternatively, MATLAB's built-in graythresh function provides automated threshold calculation.

Change Vector Analysis Implementation

Index Calculation and Change Quantification

Each pixel's change vectors comprises two components : NDVI & BSI. These vectors are plotted in the Cartesian space for the two dates, with change magnitude representing vector length and change direction indicating the type of transformation. For Landsat imagery, MATLAB's multibandread function extracts bands 4 (NIR), 3 (red), 5 (SWIR), and 1 (blue). Pixel-wise indices are calculate as:

$$NDVI = (NIR - Red)/(NIR + Red$$

$$BSI = \frac{[(SWIR + Red) - (NIR + Blue)]}{[(SWIR + Red) + (NIR + Blue)]}$$

Change magnitude (M) and direction angle (θ) are derived from the vector components:-

$$M = \sqrt{[(NDVI_2 - NDVI_1)^2 + (BSI_2 - BSI_1)^2]}$$

$$\theta = \arctan [(BSI_2 - BSI_1)/(NDVI_2 - NDVI_1)]$$

Change Classification

The significance of change is assessed by comparing observed changes against the calculated threshold. Pixels are then categorized using a change level matrix which assigns classes according to Table 1 based on the directional combinations of index changes.

Table 1: Change Dimension Classification

Change Dimension	BSI Change	NDVI Change	Description
I	-	-	Water bodies or high-moisture areas
II	+	-	Bare soil expansion
III	-	+	Vegetation increase/chlorophyll enhancement
IV	+	+	Moisture reduction/soil exposure

Results and Discussion

The GUI provides a streamlined workflow for change detection analysis. User can selected two images for comparison and the system automatically extracts and displays the relevant information. In figure 3 shows the images selection interface but in figure 4 presents the analytical option menu and in figure 5 displays the final CVA result. Illustrating change distribution across dimensions. The system supports multiple images within a designated folder. Automatically populating the dropdown menu with available datasets.

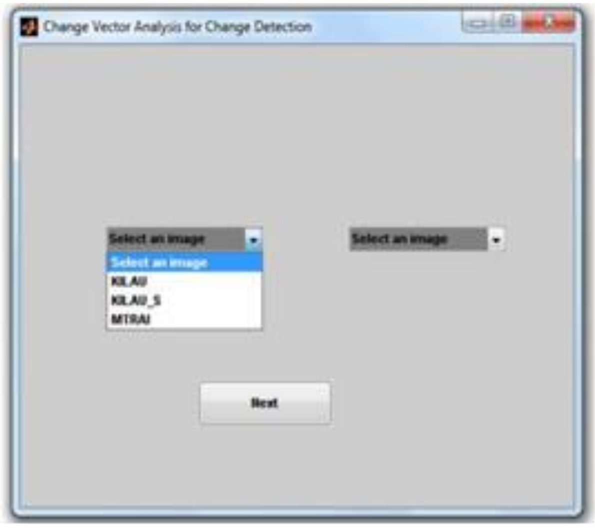

Figure 3: Shown two images on different dates

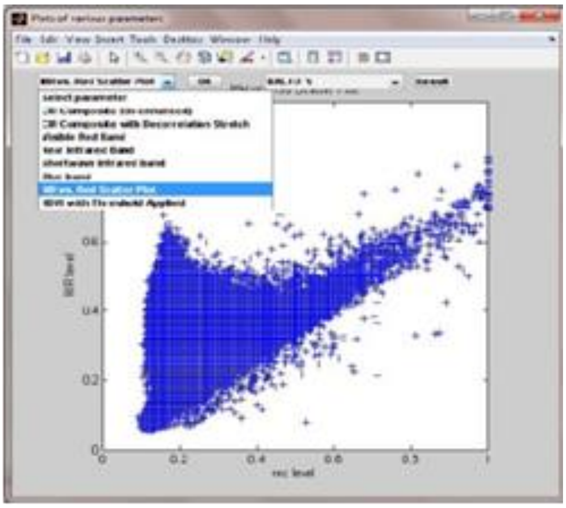

Figure 4: The plots various characteristics of image

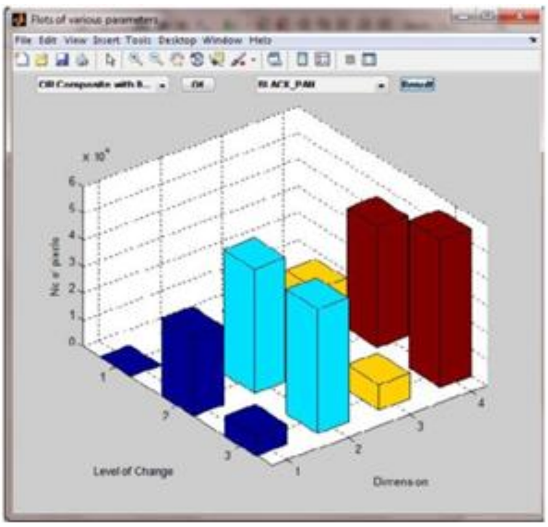

Figure 5: The magnitude of change is shown along each dimension

Conclusion

Change Vector Analysis (CVA) offers the robust framework for the land cover change detection yet optimal implementation is hindered by the challenge of selecting appropriate thresholds for magnitude and direction. The current pixel-level index calculation though thorough demands significant computational resources. In future improvements could introduce pixel cluster to boost processes efficiency. While commercial remote sensing software is available. Matlab-based GUI stands out for its accessibility and user experience. It is allows flexible comparison of multiple image pairs without repetitive preprocessing by making it an effective educational and analytical tools for rapid Satellite image assessment .

Appendix: MATLAB Code Implementation

Threshold Calculation Algorithm

```
% Extract corner regions for initial threshold estimation
col_c = floor (cols/10);
rows_c = floor (rows/10);
corners  = [ I(1:rows_c, 1:col_c);
        I (1:rows_c, (end-col_c+1):end );
% Initi
H = me
% Iter
mean_
mean_
new_H
```

Index Calculation

```
% Read Landsat bands
CIR = multibandread(landsatfile, [512, 512, 7], 'uint8=>uint8', 128, 'bil', 'ieee-le', {'Band', 'Direct', [4 3 2]});
CB = multibandread(landsatfile, [512, 512, 7], 'uint8=>uint8', 128, 'bil', 'ieee-le', {'Band', 'Direct', [5 1 2]});
% Extract individual bands
NIR = im2single(CIR(:, :, 1));
Red = im2single(CIR(:, :, 2));
SWIR = im2single(CB(:, :, 1));
Blue = im2single(CB(:, :, 2));
% Calculate indices
NDVI = (NIR - Red) ./ (NIR + Red);
BSI = ((SWIR + Red) - (NIR + Blue)) ./ ((SWIR + Red) + (NIR + Blue));
```

Change Vector Calculation

```
% Change  the magnitude and direction
```

```
change_magnitude = sqrt((NDVI2 - NDVI1).^2 + (BSI2 - BSI1).^2);

change_angle = atan2((BSI2 - BSI1), (NDVI2 - NDVI1));

% Component differences

BSI_change = BSI2 - BSI1;

NDVI_change = NDVI2 - NDVI1;

% Initialize change level matrix
level = zeros(4, 4);
% Classify each pixel
 for  f =  1:512*512
   if  (BSI_change(f) <= 0) && (NDVI_change(f)  <= 0)
       if  abs (change_magnitude(f)) == 0
              level (1,3) = level(1,3) + 1;
        end
       if abs (change_magnitude(f)) >= new_H
          level (3, 3) = level(3, 3) + 1;
       end
       if abs (change_magnitude(f)) > new_H
          level (2, 3) = level(2, 3) + 1;
       end
      end
   % The additional classification conditions for the other quadrants
   end
   % visualizer results
Bar3(level, 0.5);
xlabel ( 'change category' );
ylabel ('intensity level' );
zlabel ('pxile count' );
title ( Change Distribution Across Dimensions' );
```

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