Spectral and Spatial Parameterization of Multi-Date Satellite Images for Change Detection of Linear Features

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***Abstract* – a new technique utilizing combination of feature extraction by Change Vector Analysis and analysis of distances between features allows improvement in change detection of linear features as roads and water channels. The technique reduces that way false detection of changes due to image calibration differences, illumination differences and mis-registration. The method was applied to areas of steep climatic gradient between Mediterranean and extreme desert regions.**

I. INTRODUCTION

Change detection is most important for updating geographical and cartographic databases when considering the high expansion rates of built-up and infrastructure areas [1]. Due to high temporal environmental change in different scales, differences in imaging conditions (sun elevation, for example) and inaccuracies in the radiometric calibration and geometric corrections, a significant amount of between image changes do not represent real/significant changes. This is especially true for Mediterranean regions, which are characterized by high spatio-temporal heterogeneity. The objective of this study is to develop a technique, which allows the identification of significant changes. As changes in roads, railways, and water channels represent a considerable portion of land transformation, we chose to focus here on changes associated with linear features.

Most of the change detection techniques are based on analyzing differences in spectral properties. Change Vector Analysis (CVA) [2-3], and simple differencing [4] techniques are among the most frequently used methods. In our study, we assume that most of the land transformations, especially those related to linear features, represent significant spatial modification [1], when comparing two images of the same area, acquired at different dates. There is a lack of change detection techniques, which rely on the analysis of the physical/morphological properties of the element in question. Such properties (directionality, frequency, density and distribution) define the interaction of the elements with their surroundings and as such are also subject to natural, as well as man-derived processes. Thus, detection and characterization of change in these properties, as well, should help enhance the performance of our proposed methodology, in order to detect changes in linear features.

II. INFORMATION SOURCES

Two Landsat TM images, acquired at the end of the summer of 1992 (t_1) and 1997 (t_2), were used for this study. Landsat TM was found suitable for the purposes of the presented work, due to its spectral properties and its spatial resolution of 30m (band 1 to 5, band 7). The images were first calibrated using the empirical line method and then geo-registered one to another.

III. STUDY AREA

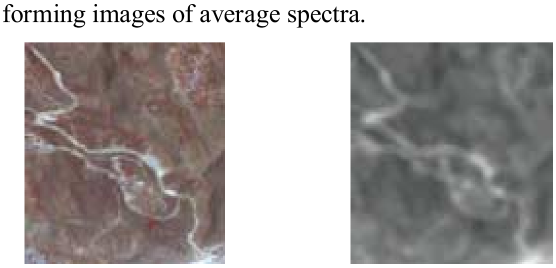
The area represents the steep climatic gradient of the Judean Desert, with a transition from Mediterranean to arid climate (700-mm annual rainfall to less than 100-mm annual rainfall) within a distance of less than 20 km. The region is characterized by high environmental heterogeneity of vegetated and desert landforms.

The significance of the study of this region for developing remote sensing techniques, which are suitable for wide Mediterranean regions and transition zones between humid and dry climates, is discussed in [5-6].

IV. METHODOLOGY

The Methodology was developed in an experimental way. It is important to note that early attempts, before detecting changes utilizing Spectral Angle Method (SAM) [7-8] and CVA between the 1992 and 1997 images, were found most unsuccessful. The spatial approach was then developed in the following 6 stages (Figure 7):

1) Low pass convolution in a window of 5X5 pixels, forming images of average spectra.



(a) (b)

Fig. 1: Low Pass convolution over 1997 raw image: (a) TM1997, and (b) LP97.

2) Change vector analysis; calculating angle and length of vectors between a raw image and its low pass image (between TM1992 and LP92 and between TM1997 and LP97).

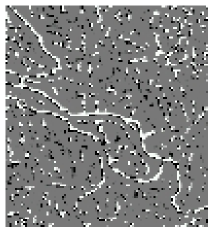


Fig. 2: CVA between TM raw and LP images.

3) Ranking the results of the vector angle of each date between 0 and 48 for a moving kernel of 7x7 pixels. Highest α values represent the features which are most different from their neighborhood pixels; thus new images were formed representing α > 36.

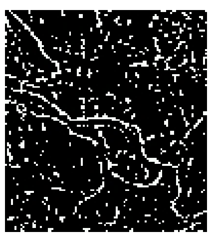


Fig. 3: Ranking over CVA

4) Buffering the resulting pixels of high α images by a 2-pixel wide zone.

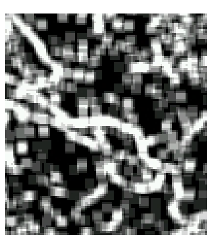


Fig. 4: Buffering of α image

5) Overlay the features of high α value (from the image of 1997) onto the buffer image of 1992.

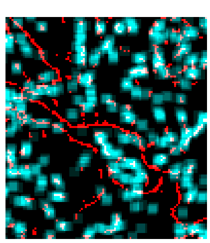
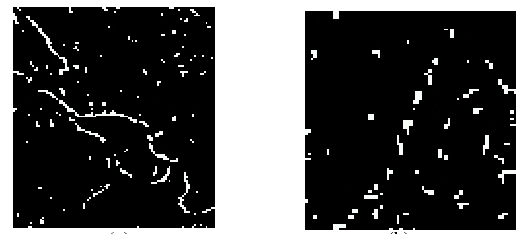


Fig. 5: Overlying: high α over buffer.

6) Conditioning the overlay image; a high α feature from 1997, which is outside the buffer of 1992 features, is regarded as significant change. As features could disappear between the two dates, the technique was implemented in an inverse form as well, i.e., overlaying the 1992 features onto the 1997 buffer image.



(a) (b)

Fig. 6: Detecting change:
(a) 1997 high α feature outside 1992 buffer, and
(b) 1992 high α feature outside 1997 buffer.

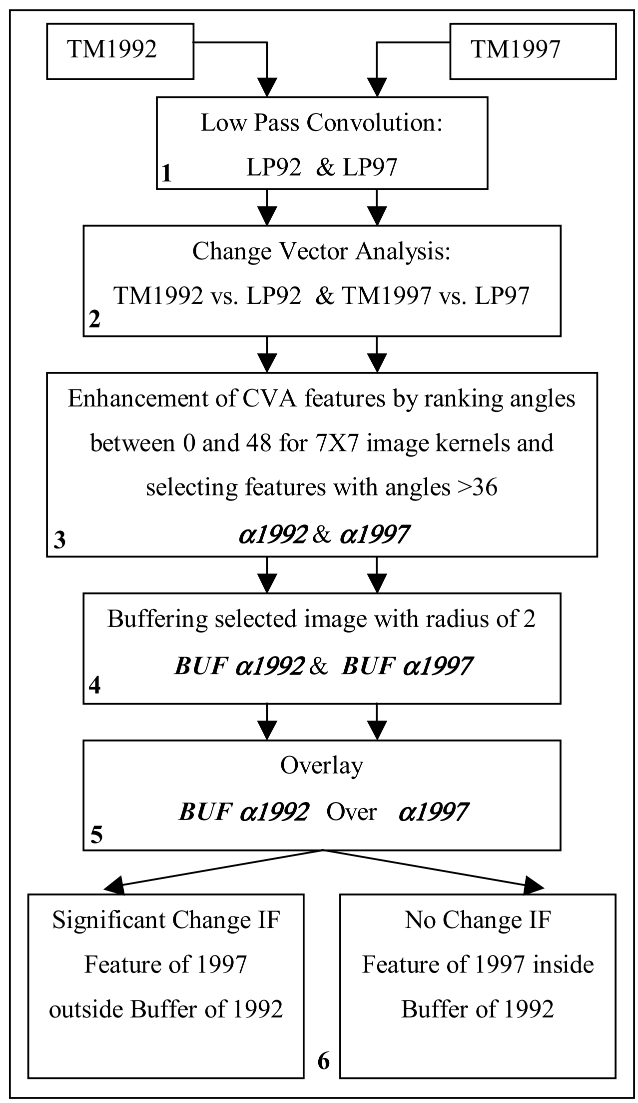


Fig. 7: Flow Diagram of Change Detection

V. DISCUSSION

Assessment of the results with visual interpretation implies high detection accuracies in all of the environments along the climatic gradient.

Determining features which are significantly different from their surrounding using the CVA method differs significantly from the traditional edge detection technique, as it enhances the multispectral differences and avoids many more edge features which represent only change in brightness. By that, the amount of noise is significantly reduced. Spatial assessment, at this point, of the distance between features was found adequate for avoiding false changes due to mis-registration.

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