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Integration of NDVI indices from the Tasseled Cap transformation for change detection in satellite images

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Abstract

Today, many problems in remote sensing are related to change detection; it consists to the characterization and localization of areas that have evolved between two times or two periods of time from two observation or sequences of observation, on the same scene. The induced changes are of different types and origins and various durations. Many methods for change detection from time series of satellite images have been proposed in the literature. These methods can be grouped into two families: the bi-temporal methods and methods of analysis of temporal profiles or multi-temporal methods. We were interested specifically in the bi-temporal method. The latter is applied to detect changes in a geographical area from acquired images at two different times. These methods are based on various algorithms for image processing. We opted to use two different methods which are: the Tasseled Cap transformation and the integration of NDVI (Normalized Difference Vegetation Index) with Tasseled Cap indices. The first approach reduces errors of omission. It consists initially to make a change thresholding on the obtained image after processing. Then, it creates a mask change to extract changes areas and to focus on the classification of these areas. Therefore, the classification accuracy is increased. The integration of the vegetation index NDVI will improve the rate of change in vegetation classes. The reliability of the results is closely related to the method adopted.

Keywords: *Remote Sensing, Landsat satellite, SVMs, Change detection, Tasseled Cap, NDVI.*

1. Introduction

The development of technology related to satellite imagery is manifested by a marked increase in the production of satellite image is a far more targeted towards many issues concerning the observation, protection or monitoring the planet. Addressed numerous issues of today are related to remote sensing change detection that is to say to the characterization and localization of areas that have evolved between two times or two periods (from two observations or sequences of observations) on the same stage. This change may be natural, for example, correspond to the growth of vegetation, volcanic eruption, flood, fire or a landslide, it can also be linked to human activity directly with urbanization, forest cuts, or crop rotation, or indirectly, including the effects of Traves polution.

The induced changes are of different types, origins and of various durations. Change detection is primary based on the ability to measure the temporal aspects of phenomena using multi-temporal well chosen data. The study [11] shows that a visual interpretation of aerial photography almost always produces better results than the numerical methods for automatic detection of changes, with a higher degree of accuracy. However, besides their high cost, the results are subjective visual interpretation which encourages the development of techniques for automatic detection, even if it is a difficult task [7]. In image processing, detecting areas of changes in pairs or image sequences of the same scene taken at different dates is a problem for many areas, such as aid to medical diagnosis [19] [2], video surveillance [20] [5] or remote sensing [6] [1] [16]. It comes to identifying the set of pixels that differ significantly between two moment or two periods. The problem is generally formulated as follows: from two images (or image sequences) I1 and I2 acquired at two times (or time intervals) t1 and t2 are different, the objective is to generate an image representing the areas of change / no change between I1 and I2, commonly called image map change. In this work we present a method for change detection based on a model that requires a methodological approach to image processing suitable for use with medium spatial resolution images, such as TM and Landsat ETM +. Such an approach is developed using images from two different years in the region of Oran, is 2003et 2010. This method combines the "Tasseled Cap" and "hybrid method", which creates a mask changes in order to isolate the changed pixels. It also allows classifiers to focus on these pixels, which can reduce the omission error of classification. In addition, Tasseled Cap indices are used to calculate the mask changes, because they enhance the information of three main elements of the biophysical coastal zone, or water, soil and vegetation. Change detection by the Tasseled Cap method seems to work well for classes belonging to two indices: moisture and shine, and very low scores for vegetation classes, that is why we opted to integrate the index NDVI is a vegetation index widely used to improve the rate of change in vegetation classes. This paper is organized as follows: in the first section we will detail the methodology used and results obtained. The second section is devoted to discussion of experimental results and we end with a conclusion.

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2. Data Used and Methodology

2.1. The Study Area

To test our approach, we used two bi-temporal images of the Oran region of size 400 x 800, taken by the LANDSAT TM7 to cover a period of seven years, the TM images of April 22, 2003 and May 5, 2010 and occupying an area of 2880 KM^2, Those are been selected since their date of acquisition is rather close in the year so that the conditions biophysics of the ground are similar (“Fig1”). A topographic map of 2009 at the scale of 1: 50,000 were used to perform geometric corrections of images (“Fig2”).

Fig. 1 The study area.

Fig. 2 Topographic map of Oran.

2.2. Methodological Approach to Change Detection and Appropriate Results

The approach of image processing is summarized in (“Fig3”). The approach of image processing features is summarized in six main steps: geometric corrections of images, the radiometric images, the Tasseled Cap transformation, the hybrid method of change detection, classification and change detection.

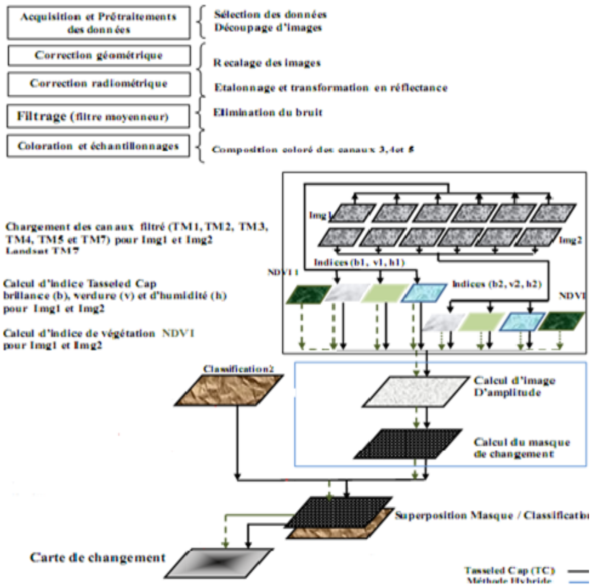

Fig. 3 Diagram of the methodological approach used for image processing.

A) Géométrique Corrections of Images

Geometric corrections were first conducted to allow superimposing the two used images. The geometric accuracy is very important for change detection. Indeed, Dai and Khorram (1998) [10] indicated that one should get less than 0.2 pixel geometric accuracy of 90% to detect real change. By cons, and Khorram Geometric corrections were first conducted to allow superimposing the two used images. The geometric accuracy is very important for change detection. Indeed, Dai and Khorram (1998) [10] indicated that one should get less than 0.2 pixel geometric accuracy of 90% to detect real change. By cons, and Khorram al. (1999) [14] recommended 0.5 pixel precision. The 2003 image was geometrically corrected using the method to image map using a topographical map of 2009 at a scale of 1: 50 000 (“Fig4”). Corrections to the 2010 image were made using the method of image- image based on the 2003 image. The root mean square (RMS) obtained is of the order of 0.11 pixel. Because the study site is taken from an urban environment where infrastructure, the control points to use for free are numerous. In light of this observation, we chose this value.

Fig. 4Geometric corrections using the method to image map.

B) Radiometric Correction of Images

Radiometric corrections are necessary helps to eliminate the effects associated with solar incidence angle and atmospheric effects, which change the spectral properties of specific categories of land tenure on the image. This approach is required in both cases. The analyst applies linear transformations in the change detection algorithm and uses the histogram changes to determine the threshold of change [4], [13], which corresponds to the hybrid method for detecting changes in this research.

C) Filtering channels

The filter used in this step is a filter of "low pass" filter called averaging (or smoothing) which replace the current pixel by the average value of pixels in a 3x3 moving window applied to all channels of both images landsat TM7 ("Fig5"). Many fine details are missing, and the image appears blurry and sharper compared to the raw image ("Fig6").

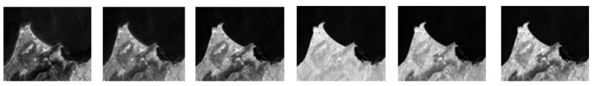

Fig. 5 raw channels TM7 -2010 :(a1: TM1), (b1: TM2), (c1: TM3), (d1:TM4), (e1:TM5), (f1:TM7).

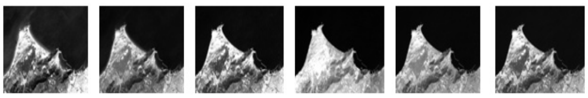

Fig. 6 filtered channels TM7 -2010 :(a2: TM1), (b2: TM2), (c2: TM3), (d2:TM4), (e2:TM5), (f2:TM7).

D) Tasseled Cap Transformation

To calculate the brightness, greenery and wetness indices [15] have also proposed coefficients, originally used for Landsat MSS [13], [9] was then recommended to use special reflectance coefficients for TM images from the equations of the Tasseled Cap transformation:

- Brightness = Σ bi* TMi; (1)
- Greenness = Σ vi* TMi; (2)
- Wetness = Σ hi* TMi; (3)

Where bi, VI and hi are the coefficients of the Tasseled Cap transformation for the calculation of brightness, greenness and wetness ("Table1").

TABLE 1: Coefficients of the Tasseled Cap transformation applied to the reflectance image of TM

Index	*TM1*	*TM2*	*TM3*	*TM4*	*TM5*	*TM7*
B	*0.2043*	*0.4158*	*0.5524*	*0.5741*	*0.3124*	*0.2303*
G	*-0.1603*	*-0.2819*	*-0.4934*	*0.7940*	*-0.0002*	*-0.1446*
W	*0.0315*	*0.2021*	*0.3102*	*0.1594*	*-0.6806*	*-0.6109*

These indexes are inserted in the process of the hybrid method of change detection. The calculation of these indices is applied to each pixel of the image 2003 and 2010 ("Fig7").

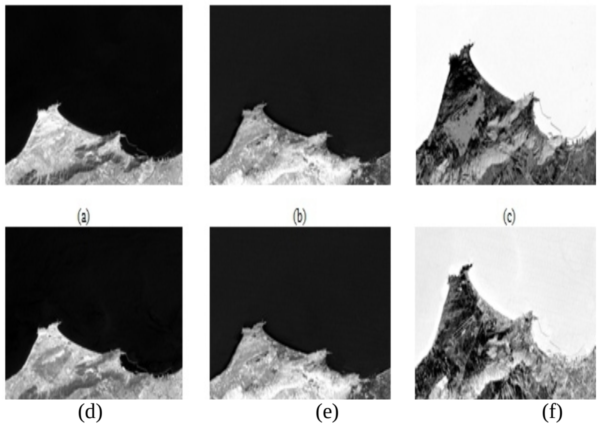

Fig.7 (a): brightness index (2003), (b): Greenness index (2003), (c): wetness index (2003), (d): brightness index (2010), (e): Greenness index (2010), (f): wetness index (2010).

D) Hybrid Method and Mask of Changes

This method involves creating a mask change. The magnitude of change (or synthesized image) ("Fig8") was calculated using Tasseled Cap indices introduced in the equation proposed by Lunetta et al. [17]:

Amplitude change (DN) = $[(\text{brigthness1} - \text{brigthness2})^2 + (\text{greenness 1} - \text{greenness})^2 + (\text{wetness1} - \text{wetness2})^2]^{1/2}$ (4)

The mask contains the values associated with pixels 0 corresponding to no change and one associated with pixels corresponding to a change. The mask is calculated from the mean (μ) and standard deviation (σ) of the image and an amplitude coefficient T using the following equation [17]:

- Maximum change = μ + Tσ. (5)
- Minimum change = μ - Tσ. (6)

Pixels are not considered changed if its value exceeds the maximum or below the minimum of changes. The higher the value of T is smaller, the number of pixels changed increases. In general, the value of T should be 1 [18], [13], because this value seems to be appropriate to describe the spectral changes in the subtraction of the bands. However, Fung (1990) [12], who conducted a study to find the best value of T, confirmed that 0.8 was the value most suitable for the best results. This last value has been used to calculate the mask changes ("Fig9").

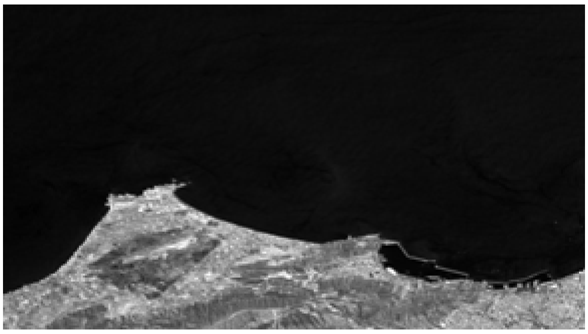

Fig. 8 Amplitude change.

Fig. 9 Change mask.

F) Classifications

A classification was performed for the entire image of 2010, and for a good classification we have tried to introduce the techniques of learning SVMs (separators wide margin) in the field of remote sensing [8]. SVMs are tools designed to solve the problems of binary classification supervised, and generalized by different approaches (one against one, one against all) to the multi-class classification. According to the separability of the data, SVMs are also distinguished by two models: linear and nonlinear. We therefore conducted a content classification of the Landsat image 2010 representing separators by wide margin according to the non-linear approach one against all ("Fig10"). The table below ("Table2") shows the results of the statistical classification made on the Oran region.

Table 2: Classification results of the image 2010 by SVMs

Classes	*Number pixel*	*Area [Ha]*	*Occupation %*
Sea	145645	1275	45.51
Surf	32978	296	10.30
Sand	4586	41	1.43
Forest	23607	212	7.37
Urban	26572	239	8.30
Cereals	24937	224	7.79
Burn	44970	404	14.05
Fallow	16705	150	5.22
Classification rate : 97.87 %			

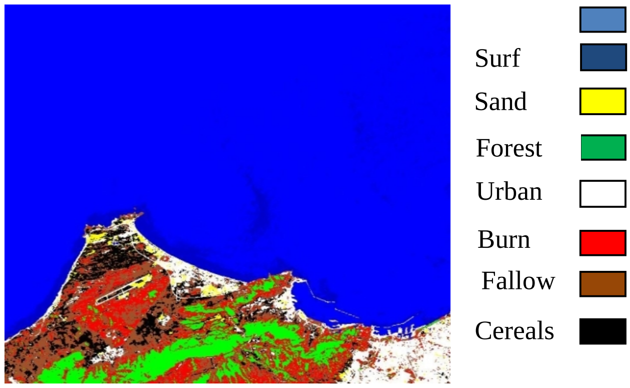

Fig. 10 Image of Oran in 2010 classified by SVMs.

G) Change Detection

Having classified the Landsat 2010 and after validating the results of this classification, we apply the mask obtained for this classification eliminated the pixels corresponding to no change in the image is kept classified the pixels corresponding to a change which we gives a change map ("Fig11"). The table below shows the result of statistical change detected by the Tasseled Cap transformation performed on the Oran region between 2003 and 2010 ("Table3").

Table 3: Results obtained by changing the transformation Tasseled Cap

Classes	*Number pixel*	*Area [Ha]*	*Occupation%*
Sea	24416	219	7.63
Surf	25440	228	7.95
Sand	9632	86	3.01
Forest	480	43	0.15
Urban	7424	66	2.32
Cereals	3936	35	1.23
Burn	352	3	0.11
Fallow	**5600**	**50**	**1.75**
Rate of change : 24.15%			

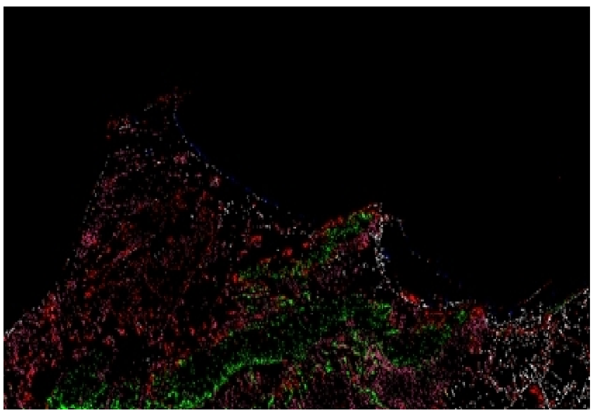

Fig. 11 Map of change Tasseled Cap.

H) The Integration of NDVI with Tasseled Cap Indices

This method consists to adding a fourth index (NDVI) with conventional indices of Tasseled Cap (brightness, humidity and green) for two pictures 2003 ("Fig12") and 2010 ("Fig13"). The NDVI is a vegetation index widely used to improve the rate of change in vegetation classes. Starting from the amplitude image we calculate the change mask that will be superimposed on the 2010 classified image to remove the card change ("Fig14"). The table below shows the result of statistical change after the integration of NDVI ("Table4").

Fig. 12 NDVI 2003.

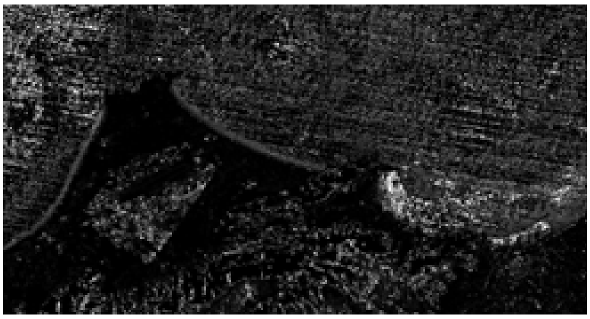

Fig. 13 NDVI 2010.

Table 4: Results obtained by changing the transformation Tasseled Cap + NDVI

Classes	*Number pixel*	*Area [Ha]*	*Occupation %*
Sea	24416	219	7.63
surf	25440	228	7.95
Sand	9632	86	3.01
Forest	2272	21	0.71
Urban	6944	63	2.17
Cereals	9856	89	3.08
Burn	608	6	0.19
Fallow	**12960**	**117**	**4.05**
Rate of change :28.79%			

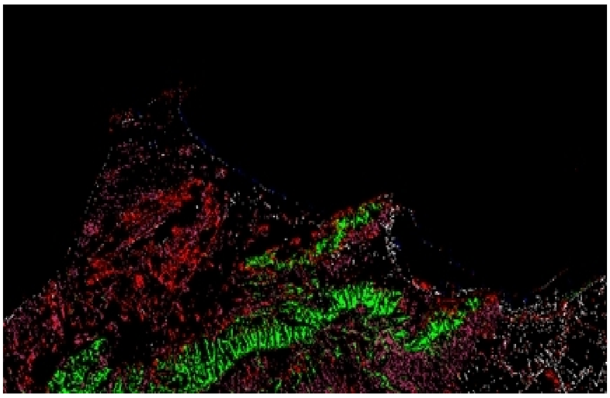

Fig. 14 Map of change Tasseled Cap + NDVI.

3. Comparison and Discussion

Change detection by the Tasseled Cap method seems to give good results for classes belonging to two indices: moisture and shine, and the very low classes for vegetable, and that by comparing these results with the ground realities. The Tasseled Cap method gives a satisfactory rate of change for sea and surf classes represented by the moisture index, and the urban classes and sand represented by the brightness index. For their against a very low rate of change for forest vegetation classes, fallow, burning and cereal represented by the vegetation index. This is an effective means of detecting changes to classes or degree of vegetation is very low. The vegetation index NDVI is a very effective way to improve the rate of change for the classes of plants are influenced on the rate of change of other classes. Are improvements in rates of change for the classes forest, fallow and cereal from the rate obtained in the Tasseled Cap, the rate of detected change became almost equal to the rate of change detected by the post classification comparison method. Note the stability of the rate of change for other classes represented by the two indices brightness and moisture from the previous two methods.

4. Conclusion

In this study, we were able to quantify the areas that have changed between 2010 2003 for the Oran region is using two different methods. Change detection by the Tasseled Cap transformation is useful for classes or degree of vegetation is very low. The integration of NDVI with Tasseled Cap indices improve in a relevant rate change for vegetation classes.

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